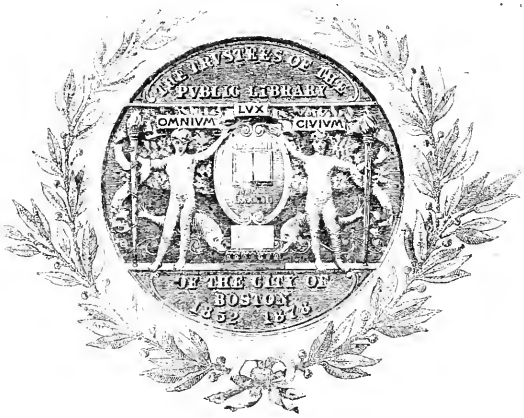
THE TRUSTEES OF THE
PUBLIC LIBRARY
OMNIVM
LVX
CIVIVM
OF THE CITY OF
BOSTON
1852 1878

WILKINS'S REVIEW

OF

REPORT OF WATER COMMISSIONERS

OF 1845.

A

REVIEW

OF THE

REPORT OF THE WATER COMMISSIONERS

OF 1845;

WITH AN EXAMINATION OF SOME OF ITS STATEMENTS AND ESTIMATES.

BY JOHN H. WILKINS.

BOSTON:
PRINTED BY FREEMAN AND BOLLES.
1846.

REVIEW.

On two former occasions, circumstances seemed to call upon me to enter, somewhat minutely, into an examination of the question of a proper source of supply of pure water for the city of Boston. The question has since undergone examination by a board of professional engineers; and a source, different from the one for which I expressed preference, has received its official recommendation. I suppose there can be no doubt that this recommendation will settle the question, and that the waters of Long Pond will be brought into the city, as early as a work of that magnitude can be well executed.

It is not with any view of operating upon public sentiment, that I now enter upon an examination of the Report of these commissioners. The question of source is a question of expediency; and, like all questions of that character, must be settled by majorities, and without undue delay. The subject having undergone full discussion, I am not about to complain that a source is to be selected which I do not prefer. As I, however, have appeared, in this matter, as an amateur only, I hope I may pursue the subject, in that character, without offence. And as the great FACTS and PRINCIPLES of the case remain unaltered, I can hardly reconcile it to my sense of propriety to allow *both* to remain in the distorted and perverted form and position in which they seem to be presented in this Report.

This Report is very elaborate. The commissioners appear to have worked diligently, and to have wrought into their Report the multiplied results of their labors. How much value, I deem, ought to be attached to these labors, either in the field or in the study, will appear as we proceed.

One can hardly go through this Report in a cursory way, without feeling oppressed with accumulation of details, facts, assumptions, and reasonings, which overlay all the important branches of the inquiry. Unless he reads merely to assent, and to confirm himself in preconceived views, he can hardly fail to entertain a suspicion that there is

a vein of fallacy pervading it, though he may not be able to detect it. It requires several readings, and a singling out of important points to be established, and a consideration of the details as they bear upon these points, before a just appreciation can be formed of the "sayings and doings" of these commissioners.

For instance, one is almost amazed at the amount of labor and attention, given by the commissioners to ascertain the proportion of the whole fall of rain that is made available for the supply of the ponds. It is almost appalling to reflect how much study must have been given to the matter, and how many sums must have been wrought, to say nothing of the out-door labor in making observations. Now, if it should appear that this labor and this study have been of absolutely no use whatever in establishing any important point of inquiry, and that, in fact, these commissioners themselves have been obliged to abandon their own deductions from their own observations, I suppose others will think, with me, that this labor and this study is lost, so far as the particular objects in view are concerned; and that good taste, as well as economy of time, both on the part of the commissioners and their readers, would not only allow, but require, the whole to be omitted. And what an inroad upon the magnitude of this volume would have been made, had such an omission taken place!

Let us examine a little more particularly the value of the investigations of these commissioners into the proportion of the whole fall of rain that passes into Spot Pond.

On p. 4, the comissioners, after stating various results, deduced by various observers in Europe, say: "It may be observed that experiments have been made in this country that show, under circumstances essentially similar to the cases (i. e. Long and Spot Ponds) under consideration, that from $\frac{1}{3}$ to $\frac{1}{2}$ of the annual fall of rain may be collected in the reservoir," or pond.

Here we have stated the general rule, the *a priori* expectation. Now, if, in the very first application of this general rule, it is found to fail, and the *a priori* expectation is destined to be disappointed, it would seem to be in better taste to have omitted all reference to it. Now the result must, inevitably, be to create distrust of the soundness of the rule, or of the correctness of the observations by which it is impugned, unless the causes of the differences be pointed out.

A certain state of facts existed, in relation to Spot Pond, at the time of observation by these commissioners, which must be noticed. Messrs. Treadwell and Hale had measured it in 1837 and 1838. They had stated the quantity of water which flowed from that pond during about 20 successive months. The quantity of rain which fell

in Boston, and also at Waltham, during those 20 months, was known; and there was no known cause why nearly the same quantity of rain should not have fallen at Spot Pond as at Boston or Waltham. Hence, after having obtained the area of drainage into the pond, the necessity was upon these commissioners of pointing out errors in the measurement of the former commissioners, or of admitting such a proportion of the rain to be caught or drained into the pond as would supply the measured quantity. Now they could hardly venture upon a correction of errors; for they took substantially the same apparatus, and other means, for their own admeasurements, and there had in the mean time been no alteration in the condition of the pond. They were, therefore, forced to admit that, if the rain at Boston, from April 1st, 1837, to April 1st, 1838, be taken as the quantity falling at Spot Pond in the same time, the proportion passing into the pond, was over $\frac{7}{10}$ of the whole; and if the Waltham guage be taken, then little over $\frac{5}{8}$ of the whole passed into the pond. In either case, the proportion far exceeded the *a priori* expectation derived from other cases in this country, where, it is stated, the "circumstances were essentially similar" to this.

Such being the facts in relation to Spot Pond, and these commissioners themselves acknowledging that, "had a rain-guage been accurately kept in the district, it should be regarded as conclusive" (p. 8); what could have induced these commissioners to go on with partial and temporary observations, the results to be deduced from which they could not but have felt bound to make conform to previous observations and well established facts?

But these commissioners did see fit to go on and make observations for themselves. It is needless, and it would be tedious, to follow them through all the labyrinth of detail, which constitutes their description of this operation. I go, at once, to the results, as stated on p. 14. It here appears that, during 85 days, (near 3 months,) the average proportion of the whole fall of rain on the district, during that period, which passed into the pond, was less than $\frac{1}{6}$; less than $\frac{1}{6}$, for 3 months, when they knew that, for 12 months, it must be near $\frac{4}{6}$, or near 4 times as great.

A singular, and perhaps somewhat startling inference seems to be deducible from this result. Let us suppose that, from the 1st of April, 1837, to the 1st of April, 1838, the same amount of rain fell at Spot Pond that did at Boston;—and it is difficult to see why it may not have been less as well as greater. Let us also suppose that the 3 months, August, September and October last, shall constitute a portion of 12 successive months, in which no more rain will fall than there did between April, 1837, and April, 1838; a very supposable case, and

one which may be entirely true for all that the commissioners could know at the time they made their report, and may be true, probably, for anything they may know now.

It appears that, from April 1st, 1837, to April 1st, 1838, 30.2 inches (p. 6) of rain fell in Boston; and by our statement, the same is supposed to have fallen at Spot Pond, at the same time, and also in one year, embracing the 3 months just named. Of this, 30.2 inches, 71 per cent., or 21.442 inches, was found by actual measurement to have gone into the pond; and if the same amount fall this year, the conditions of the pond remaining unchanged, it may reasonably be presumed that the same proportion will pass into the pond.

Now the commissioners inform us (p. 14) that, during August, September and October last, 10.17 inches of rain fell. Of this, there passed into the pond only 16.6 per cent., = 1.688 inches. Deduct this from 21.442, the whole amount to be caught in the year, and we have 19.754 inches, to be caught in the remaining 9 months. But 10.17 inches, out of the whole 30.2 inches of the year, have fallen; and only 20.03 remain to come. Take from 20.03 inches, the amount to fall, 19.754 inches, the quantity to be caught, and we have .276 of one inch to be lost. So that, while 10.17 inches are falling, $8\frac{1}{2}$ inches are lost; and while 20.03 inches are falling, only about $\frac{1}{4}$ of an inch must be allowed to be lost. Had observations begun sooner, or continued longer, so as to have embraced a single smart shower more, and with the same results, and it would have resulted that, in the remaining 9 more, it would be necessary to catch more water than would fall.

Now, in all sincerity, I would ask, What are such labors worth? Who would risk a groat in any investment, a fair return for which should be dependent on the accuracy of any conclusion to be drawn from them?

But I have not done with this case. In spite of their own observations, the commissioners assume that $\frac{6}{10}$ of the rain falling on the area of drainage is saved to the pond. (p. 16.) I have already stated that, if the Boston rain-guage for 1837 be taken, this ratio is over $\frac{7}{10}$, but if the Waltham guage, it is over $\frac{5}{8}$, the decimals being .71 and .628. (pp. 6, 7.) By taking the Waltham guage (substantially,) instead of the Boston, (the reason for which I shall presently examine,) the commissioners have assumed some risk, and have not erred on the safe side, if there be error. For the Boston guage (though not differing from the Waltham much *on an average*) shows greater extremes: 9 years in 27 (or $\frac{1}{3}$ of the years) exhibiting a fall of less than 36 inches, and in one year of less than 30 inches; while the Waltham guage, only 3 years in 20 (or about $\frac{1}{7}$ of the years,) ex-

hibited a fall of less than 36 inches, and in no one year less than 34 inches. Now, if there should be reason to suppose that the Boston guage ought to be taken, instead of the Waltham, the commissioners would be obliged to raise the proportion of rain caught from $\frac{6}{10}$ to $\frac{7}{10}$; because, in the very driest year (1837,) by the Boston guage, that proportion was actually saved, while a considerably less proportion was saved, if the Waltham guage be taken. It is not, therefore, on the principles assumed by these commissioners, a matter of indifference which guage be assumed; for there is a difference, in dry seasons, of 14 or 15 per cent. between them, — a difference sufficient, under some circumstances, to produce great distress. It becomes, therefore, a matter of some importance to examine the reasons, given by the commissioners, for relying upon Waltham guage instead of the Boston.

The first, and most ostensible, reason appears to have been the *greater proximity* of the Waltham guage, over the Boston guage, to Spot Pond. They say (p. 16): "The guage kept by Dr. Hale, at Boston, is about 8 miles from the centre of the district (of Spot Pond,) and that kept by Dr. Hobbs, at Waltham, is between 5 and 6 miles;" and on the following page, they refer to the Waltham guage as "being nearest in location, and perhaps most applicable."

Now, no one, at all conversant with the general direction of Spot Pond and of Waltham factories from Boston, need to be informed that here must be a mistake. Spot Pond lies nearly north, and Waltham factories nearly west, from Boston. I recurred to Boyden's large map of the State, as the most recent, and probably most accurate, authority; and, on measuring accurately the distance from the centre of Boston, and from the location of the factories in Waltham, to Spot Pond where it borders on the Andover turnpike, (which is the nearest point to both Boston and Waltham,) I found the distance exactly $\frac{3}{4}$ of an inch greater from the Waltham factories to Spot Pond, than from Boston to Spot Pond. And as the scale of this map is $2\frac{1}{2}$ miles to an inch, this result shows that the Waltham guage, instead of being nearer than the Boston one, is $1\frac{7}{8}$ miles more distant, or quite 25 per cent.; and instead of being between 5 and 6 miles, is distant between 9 and 10.

I then consulted Hale's map of Boston and vicinity, which was drawn from actual survey; and the result was the same as with that of Boyden.

I recollected that these commissioners had themselves given a map of the localities treated of in this Report; and, as consistency is a jewel, I expected this map would be made conformably to the letter-press, or that the letter-press was made conformable to the map. But I was mistaken. The map appears to be correct. The distance

upon it, from the location of Waltham factories to Spot Pond, is just $\frac{7}{10}$ of an inch greater than from the centre of Boston. We are not informed upon what scale this map is drawn; but as this $\frac{7}{10}$ of an inch is just $\frac{2}{7}$ of the whole distance from Boston to Spot Pond, it must represent a little less than 2 miles,—probably exactly $1\frac{7}{8}$, as deduced from the other maps.

We see then, that, whatever preference is to be given to either guage on the ground of proximity, should be given to the Boston guage, clearly and decidedly, and not to the Waltham, as is done by these commissioners.

The second reason for the preference of the Waltham guage by these commissioners, appears to be less ostensible, though no one can doubt that it was much more weighty than the first. They say (p. 17): "As only 3 years out of 20 fell below 36 inches, it may be regarded as reasonably safe to assume 36 inches as the annual fall, and *more especially*, as this will not, on the ratio of $\frac{6}{10}$, materially exceed the lowest guage of the commissioners of 1837 and 1838." No doubt, this is the true philosophy. No one will dispute the satisfactory nature of this reason. Having settled it in their minds, though without any evidence, that "a ratio (p. 16) of not more than $\frac{6}{10}$ of the total fall of rain may be relied on," they felt really obliged to assume such a fall of rain as would give as much water, on this ratio, as Hale and Treadwell found there. The difficulties attending any other course were too hazardous to be encountered. And the necessary fall of rain, upon this principle, was found to be nearer to the minimum of the Waltham guage than of the Boston; and hence the preference given to the former.

The same, or similar inconclusive and unreliable character attaches to all the doings and calculations of the commissioners to ascertain the ratio of rain preserved in Long Pond. They had more license in regard to Long, than Spot, Pond; for the commissioners of previous years had not examined it so long, or so accurately, as they had Spot Pond; and the circumstances of this pond had also changed since any previous examination,—the surface having been raised several feet, in the last winter, for the first time. There was not, therefore, the same necessity upon the commissioners of 1845, to respect the results of previous examinations, in this case, that there was in that of Spot Pond. Hence we find some deviation in the results of these commissioners from those of former years. For instance, they estimate a larger quantity of water reserved in the pond, than the commissioners of either 1837 or 1844. But a character of doubt and uncertainty pervades the whole of their statements and calculations; and few sane men, I apprehend, could be found, who would risk a

dollar, the prospect of seeing which again should be dependent upon the correctness, or the certain nature, of the deductions made by these commissioners.

Before I proceed to graver matters, it may not be amiss to notice here some out and out mistakes, which, from whatever cause they arise, cannot but be regarded as greatly marring a document of this kind, which should be characterized by *absolute* correctness.

On p. 11, in the lines from 15 to 11 from bottom, the sums .065 + .076 + .062 are made = .213, which is not true.

On p. 12, first paragraph, the sums .2121 + .4416 are made = .6937, which is not true.

On p. 68, is the following table, viz. :

	Spot Pond.	Long Pond.	Charles Riv.
Average temperature of air,	62° 81	61° 11	60° 94
" " dew point,	54 42	53 72	53 91
" " water,	67 35	67 14	63 02
Diff. between air and dew point,	8 39	7 39	7 03
" " water and dew point,	12 93	13 42	14 11
" " water and air,	4 54	6 03	7 08

If the reader will take the trouble to examine this table, he will find that, on the supposition of the first three lines being correct, the figures 14° 11, in last column, should be 9° 11 ; and the figures next below 7° 08, should be 2° 08.

Just below the table, is the following sentence : " From these facts, it appears that the surface of the water, at these several sources, maintains generally, in hot summer weather, a higher temperature than the superincumbent air ; amounting, on an average of the three sources, to about 5° 88, — Charles River having the greatest excess." By making the corrections suggested above, this average is but 4° 22, instead of 5° 88 ; and Charles River has the *least*, instead of the *greatest*, excess, as here asserted. Other like errors have been noticed.

These mistakes have occurred on casual reading, without effort to detect them. Perhaps others may have been detected by other readers, in the same manner. All these errors lay, as it were, on the surface — in plain daylight. But the reader will bear in mind that far the larger part of the calculations are indicated by signs, and only the results are given. Whether these results be correct, will, I apprehend, never be known. But from mistakes, which the eye detects in the simple, plain processes, may be inferred those which, probably, exist in the complex and abstruse. *Ex pede Herculem : ex minimis majora.*

There is a certain ostentation in the description of the modes of making observations and of deducing results, pervading this pamphlet, that strikes me as anything rather than the dictate of good taste. Four out of five of the readers will not comprehend the bearing and scope of them; and many of those who do, will not attach much importance to them. There appears to me, also, to be a display of science and knowledge, which might be pardoned in a tyro, but is intolerable in a document of this importance, especially as it is often of a suspicious character, and sometimes downright error.

Speaking of the greater demand (25 per cent.) that will exist for water in the summer, over the average of the year, and the necessity of providing for its attainment, they say (p. 26): "We have been more explicit in stating this point, because it does not appear to have engaged much attention from those who have heretofore examined the subject." Now, what is the evidence that the commissioners of 1844 did not take this into consideration? They did not see fit to distract public attention by adverting to it; but as they provided the same conduit which these commissioners have adopted, it is difficult to see why they did not, in fact, provide for it just as much as these new commissioners have. I apprehend they will hardly admit that it did not engage an adequate degree of attention.

But, however this may be, it certainly did not escape my notice. In *Further Remarks*, (pp. 58 and 59,) I noticed this greater demand in summer, than an average. I did this, it is true, to draw an inference, different from any drawn by these commissioners; but it never occurred to me that it was a new idea, which might not have been fully considered by the commissioners of 1844 in projecting their plan; and I wrote these *Further Remarks* with no disposition to overlook any important omission on their part.

But it is a little amusing to notice how entirely these commissioners forgot this point, in an important particular, as they went on. In all their estimates of delivery, from each source, up to an average demand of $7\frac{1}{2}$ million gallons per day, this extra demand is provided for. But, in various places, they state that the pond will yield 10 million gallons per day, that the work they propose will deliver 10 millions per day, and they express the opinion that the time will soon come when there will be an average demand for 10 millions per day; and they urge that, for these reasons, the works they have proposed, and not those of less capacity, should be adopted. In all they say, on this point, they appear to be utterly oblivious of the fact that, when there is an *average* demand of 10 millions per day, there will be *temporary* demand for $12\frac{1}{2}$ millions per day;—a demand which there is no pretence set forth, in this Report, that the proposed works have a

capacity to supply. In point of fact, when there is an *average* demand of $7\frac{1}{2}$ million gallons per day, there will be, in the summer months, a demand of nearly, or quite, 10 millions per day,—the full capacity of the proposed conduit to deliver. So that, on the principles adopted by these commissioners, it would appear to be idle to rely upon their proposed works for a greater average supply than $7\frac{1}{2}$, or, at most, 8 million gallons per day.

The alternative, contained in the following quotation, I apprehend, is new. Speaking of bringing iron pipes, across Charles River, from Charlestown to Boston, they say (p. 20): "The pipe must go over and above the masts of vessels, or below their bottoms." Though there have been several plans and estimates published, for crossing the river at this place, and although no one can question the truth of the position here taken; yet I much doubt if the alternative ever entered the head of any preceding engineer. It is, however, but strict justice to these engineers to quote the next sentence,—"To go under, is the only plan now to be considered." It would seem, therefore, that they did not spend any time in making estimates for carrying the pipes over the masts of vessels; but it would also seem, from the use of the word *now*, they looked to doing so at a future time!

In passing, I beg the reader to understand that the matters I have been animadverting upon, I do not deem, in themselves, of the slightest importance; for they, really, have no bearing upon any important point in the inquiry in hand. My only object is to exhibit the quality of mind which has been employed upon the matter; and to show how far its operations depart from that simplicity and philosophical exactness which ought to adorn such a report, and which, I feel bound to say, has hitherto characterized the official reports made upon this subject.

But to proceed in our work. On p. 39, these commissioners have a "Table showing the fuel consumed, the duty performed, &c.," at the new Philadelphia water-works. Now, in deducing the *duty performed*, they assume that the engine, in raising the water 115 feet, the height of the reservoir, operates under the resistance of a column only of 115 feet. This would be correct if the lift were perpendicular. But as the reservoir is nearly, or quite, $1\frac{1}{4}$ miles distant, allowance should be made for increased friction. The commissioners of 1837 allowed this friction, in the course of $3\frac{1}{4}$ miles, to equal a column of water of 33 feet; and, in the same ratio, the friction in $1\frac{1}{4}$ miles should be equal to about 12 feet. So that the Philadelphia engine should be considered as operating under the resistance of a column of 127 feet, instead of 115,—or an addition of more than 10 per cent.—which will increase the duty in the same degree. It is

true that the commissioners mention this circumstance, 4 pages farther on; but it is done in an entirely different connection, and no cursory reader would ever think of making the allowance.*

On pp. 108 and 109, is this paragraph:

"From the Report of the Royal Commissioners of Great Britain, for inquiring into the state of large towns and populous districts, it appears that, with the exception of the city of London and its precincts, few of the towns in that country are supplied with water, in such a manner as to furnish it to all the inhabitants within their dwellings, under high pressure, and without the intervention of human labor to bring it within their reach. Only in *six* instances could the arrangements be considered *good;* in *thirteen* they appear *indifferent;* and in *thirty-one*, so deficient as to be pronounced *bad.* The commissioners say, 'The important advantages afforded by a constant supply of pure water, kept on night and day, and superseding the necessity for the use and expense of water butts and tanks, are stated in the evidence of several eminent engineers, connected with the water-works in various places.'"

The Report here referred to was made June 27th, 1844, and is the same referred to so often by Mr. Hale and myself.

Now, from this language, what is the reader to conclude to be the situation of London and its precincts?—by which is understood the same as by the metropolis of London. Can there be any other meaning than this, that all the inhabitants of that metropolis (and a few other towns) are furnished *within their dwellings, under high pressure, and without the intervention of human labor to bring it within their reach?* Please read the paragraph again, and see if there can be any other meaning.

What, then, are the facts, as to London, in these particulars? All the inhabitants, here, have the water *within their dwellings* that will pay for it, and stand pipes and public hydrants supply the poor. In this respect, London forms no exception to the other towns or cities where adequate works are constructed. In respect to *high pressure*, the inhabitants of London do not have it at all. The water is let on, for their use, certain hours or days in each week, and it has to be caught and stored in water butts, tanks, tubs and buckets, or any other vessels that they may chance to have, for use, until the time comes for it to be let on again. If, by the terms *without the intervention of human labor to bring it within their reach*, it means the same as having it brought *within their dwellings*, this condition is

* It is, probably, owing to this allowance for friction, that Mr. Hale, in his *Enquiry*, &c., p. 40, reckons the height of the reservoir at 127 feet, instead of 115; that being the measure of resistance to be overcome.

already sufficiently noticed. But if it means, as I suppose it does, from its connection with high pressure, that the Londoners have it delivered in the apartments where it is wanted, and without the intervention of human labor to carry or raise it from the cellar, where it is usually received, then it is a mistake, as the water is not delivered in London in this manner, as it undoubtedly is in the other "few towns," with which London is here classed. Hence it is an entire mistake to put London into the same category (as these commissioners appear to have done) with those few towns which, beyond question, enjoy "the important advantages afforded by a constant supply of pure water, kept on night and day, and superseding the necessity for the use and expense of water-butts and tanks." What London is really an exception to, and which probably led the commissioners into this mistake, will appear presently.

Our commissioners here say: "Only in *six* instances could the arrangements be considered *good;* in *thirteen* they appear *indifferent;* and in *thirty-one*, so deficient as to be pronounced *bad.*" The particle *only* here applies to the first clause of the sentence; and the meaning which is naturally conveyed, and which there is no indication in this report that the commissioners did not intend should be conveyed, is, that there are, among "the large towns and populous districts" of Great Britain, *only* six where the arrangements for a supply of water can be considered good. Now nothing is farther from the truth than such an assertion. A dozen such places can be named by any one conversant with the subject, where the arrangements are perfect and the supply abundant; and I cannot but regard the negligence of the commissioners to explain the matter, (if, indeed, they understood it themselves, which nowhere appears,) as quite unpardonable.

The facts are these. The royal commission of inquiry was a *sanatory* measure, instituted for the purpose of obtaining information that should be the basis for legislation, with a view to ameliorate the condition of the laboring and poorer class of inhabitants in densely populated towns and districts. It was, therefore, the object of the commissioners to push their inquiries in those populous towns and districts where theseclasses appeared to suffer most. They therefore consulted the bills of mortality, and agreed to take as places for their inquiry fifty towns or cities where the ratio of mortality should generally be found most to exceed the average, or 2 per cent. But into this category of inquiry neither London, nor many other towns and cities which are well supplied with water, came; because their mortality did not exceed the average, or did not exceed it so much as others.

Now, it is the result of the inquiries of the royal commissioners in

these fifty places, selected on this principle, that our commissioners have here given, say,—

Well supplied,	6
Indifferent,	13
Bad,	31
Making in all	50

But the metropolis of the empire, although its condition did not, on the principles adopted, make it a place for inquiry, was yet too important to be overlooked; and this on many accounts; so that, in point of fact, the commissioners were probably even much more particular in their inquiries here than anywhere else; because their inquiries could be better answered here than anywhere else. But, in stating the result in the places selected on the principle named, London was excluded, or made an exception; and this circumstance seems somehow to have led our commissioners to place London in position of an exception, on points where she is no exception at all.

That 6, out of 50 such places, should be well supplied with water, is more perhaps than ought to have been expected, instead of less. Now, it should be in mind that these 50 places were selected on a principle that would lead the commissioners to suppose they were poorly supplied with water, or, in other words, they were selected *because* their supply was deemed insufficient for the purposes of health; and in all but 6 cases it was found so. Instead, therefore, of the idea that these commissioners could find only 6 "large towns and populous districts" well supplied with water, the true idea should be, that they found only 6, out of a limited number; and this number consisted *entirely* of such places as were attended by circumstances justifying an expectation that they were poorly supplied. The wonder really is, that they found any.

In 1825, Mr. Treadwell, relying upon the authority of Professor Leslie, who states that the rivalry of the several (London) water companies almost deluged the streets, puts the consumption of water in London at near 30 gallons per inhabitant. In 1834, Col. Baldwin, relying upon the Report of a royal commission of 1828, as quoted and referred to by a Mr. Williams, in his work on *Sub-ways* in London, (p. 14, Baldwin's Report,) estimates the consumption, per head, at about the same. In 1845, our commissioners, relying upon a work published in 1829, entitled "*A Treatise on the Police and Crimes of London*," which appears to have been based on the Report of the same royal commission of 1828, estimate the consumption the same as Messrs. Treadwell and Baldwin. Mr. Baldwin's table (p. 14,) obtained from Williams's book, is the same, in its important columns,

(with the exception of a single figure, which must be a misprint,) as that furnished by our late commissioners (p. 108,) and which they seem to have obtained from their intermediate authority.

Here, then, we have *two* authorities brought in to justify the estimate of our commissioners. As to the first, Professor Leslie, he accompanies his statement with a remark, which implies that the supply was too great, and that much was wasted, owing to the rivalry of the companies. As to the second, how accurately the intermediate authors, relied upon, have exhibited the results reported by the commissioners, we have not the means of knowing. Could we inspect the Report itself, we might find statements materially qualifying those which are exhibited to us. Perhaps the rivalry, referred to by Professor Leslie, still continued at that time; and it may have been as obvious to the commissioners, as it appears to have been to Professor Leslie, that there was too much water supplied, and great waste ensued.

But, however this may have been, it is high time that the public should be disabused in regard to this extravagant estimate of the London consumption. Instead of resorting to second-hand authority, sixteen years old, our commissioners ought to have opened their eyes to facts before them, and which they could not doubt, and which could not but force the conviction, if they would but attend to their import, that the general idea of the consumption in London was vastly over-estimated. Why it is that these commissioners, and others, continue to repeat, and attempt to prove, a degree of consumption in London which no sensible man on that side the water now believes, is unaccountable to me.

Although I have been over this ground before, I seem to be called upon to go over it again.

In the Report of the royal commissioners of 1844, a copy of which our recent commissioners appear to have had, there is abundant evidence that the general, large estimate of London consumption was disbelieved by several engineers, and there is no evidence that it was believed by anybody. How the commissioners themselves viewed the matter, will appear by-and-by. Without referring to other engineers, whose names would not perhaps carry much weight with us, I will advert to the testimony of Mr. *Thorn*. This gentleman, though a cotton manufacturer by trade, has, probably, constructed more water-works for the supply of cities and towns, and is better acquainted with the state of demand that will attend any given circumstances, than any man in Great Britain. (Perhaps an exception might properly be pleaded in behalf of Mr. Wicksteed.) It must be borne in mind, too, that his system is, *never* to rely upon pumping, or mechan-

ical means, to obtain a supply. As, therefore, he never had the fear of this expense before his eyes, he would naturally be inclined to entertain and propagate ideas of large consumption. He is quoted by our commissioners (p. 109) as stating that, "I am clearly of opinion that no town ought to be considered as fully supplied with water, unless the pipes are kept constantly full, and arrangements made by which a powerful force of water can be taken from them, at a moment's notice, to extinguish fire in any part of the town, high or low." This was his theory; and I know of no reason to doubt that, in every instance where he constructed water-works, he fully attained these objects. Now, it is very clear that this theory, and this practice, favor the greatest amount of consumption. In his answer to question 136, he says: "When I speak of the supply, I always mean 2 cubic feet, or about 13 (15 wine) gallons, per diem, for every individual of the population." "*Quest.* 137. Are you aware that this is very much below the consumption of London? [This question shows the impression of the commissioners at this stage of the inquiry.] *Ans.* I am aware that it is so stated; but, as a family supply merely, I rather think it will be found to exceed that of London. *Quest.* 138. Have you made inquiries upon that point? *Ans.* Yes. *Quest.* 139. Do you know what the returns of consumption have been from the water-works in London? *Ans.* I do not, at this moment, recollect them; but I have seen them, and heard them explained." (This was a privilege, probably, not enjoyed by the authors of *Sub-ways of London*, and *A Treatise on the Police and Crimes of the Metropolis.*) "Judging from my knowledge of the facts in other towns, I should say that the quantities set down are rarely delivered." Mr. Thorn, then, enumerates many places, fully supplied with water, where the consumption is, *for all purposes*, much less than his estimate of a *domestic* supply. The probability is, that this testimony of Mr. Thorn had great effect upon the commissioners, as will hereafter appear.

Let us now pass from these opinions of Mr. Thorn, which were also entertained and corroborated by several other witnesses, to some facts furnished to these commissioners.

Among the engineers who gave testimony before the royal commissioners was William C. Mylne, Esq. "*Quest.* 5711. Are you (to Mr. Mylne) a civil engineer? *Ans.* Yes. *Quest.* 5712. Your father built Blackfriars Bridge, and was engineer to the New River Water-work; did you succeed him in the latter capacity? *Ans.* Yes." In answer to the next question, Mr. M. states that he has "been extensively engaged, as an engineer, in drainage and other works, and been consulted, with respect to the supplies of water, in different

parts of this country (England) and abroad." I make these quotations to show the standing of Mr. M., his experience, and opportunity for being familiar with matters of this kind. In answer to a question in No. 5760, Mr. Mylne says, "The population within the district (New River) is nearly 900,000 individuals." In answer to question 5716, viz., "What is the quantity of water at present distributed by the New River Company?" he answers, "The average annual quantity of water supplied by the New River works, for the last 3 years, has been 614,087,768 cubic feet." A cubic foot is $7\frac{1}{2}$ wine gallons. If, then, we reduce these cubic feet to wine gallons, and apportion the number among 900,000 inhabitants, each will be found to receive, almost exactly, 14 wine gallons per day.

Now, I will not mock our commissioners, by asking where *better* authority on this point (as far as it goes) can be found; but I will seriously ask, Where else can any be got so good? where, and how, can any be produced so definite, and so entirely worthy of all confidence? And, in all earnestness, I wish those who entertain a lingering belief in the old notion of the London consumption coming up to 30 gallons per day per head, will feel called upon to explain away, or get over, this evidence.

It is true that Mr. Mylne's testimony does not cover the whole ground,—in fact, a little less than half of it. The next inquiry, then, is, Are there reasons for supposing that the other companies, on an average, distribute materially more water, per head, than the New River does? According to the table furnished by Col. Baldwin (p. 14,) and repeated by our commissioners (p. 108,) the New River Company furnished $\frac{13}{29}$ of all the water furnished by all the companies in 1828. The present population of the New River district (900,000) is very nearly $\frac{13}{29}$ of the whole population of the metropolis. This being so, I think I may fairly require of my opponents, in this matter, to give some facts, or substantial reasons, tending to show that the New River Company do not deliver *now* $\frac{13}{29}$ of all that is delivered, as it is represented to have done in 1828. I certainly am ignorant of a single reason why the eastern, the southern and the western portions of the metropolis should, in the aggregate, have demand for more water than the central and northern, which constitute the New River district.

It is true that the evidence of Mr. Quick shows a greater consumption, per head, in the Southwark district, than in the New River, it being there a little less than 19 wine gallons per head. In explanation, however, he says, "A large proportion of our district is *entirely* manufacturing." He says that "1000 tenants (or 6 per cent. of the whole,) whom we call consumers, having manufactories,—tan-

ners, fell-mongers, hair-washers, glue-makers, curriers, dyers, brewers, distillers, steam-engines, railway stations, hospitals, &c., — all use great quantities of water, and most of them have tanks below the level of the street." Such being the character of this particular district, the wonder is that the consumption does not average more than 19 wine gallons per head, especially as the proportion of those who take water, to those who do not, is decidedly greater than in the New River district. But, if this district requires more for manufacturing purposes than the New River district does, other districts will require less. I see no reason to doubt that the New River district is a fair sample of average demand for all purposes.

Now, what was the effect of all this and other testimony upon the opinions of the commissioners? There is reason to suppose that they commenced their investigations under the general impression that the London consumption was near 30 wine gallons per head. After going through with their inquiries, they finally report that, "in estimating the quantity for a *domestic* supply, we think that, in all cases where an ample supply can be procured, it ought not to be calculated at a less rate than 12 ($14\frac{2}{5}$ wine) gallons, per diem, for each individual of the population." This is 1 imperial gallon less than Mr. Thorn's estimate of a supply. It must be borne in mind that this estimate is for circumstances entirely novel. They recommend that local authorities be *required* to furnish a supply of water, and every house be *required* to take it. If this recommendation be adopted, the result will be that everybody will take and use the water. Now, an estimate, allowing 12 gallons per head, under circumstances which insure that everybody will take and use it, is not more than equivalent to an allowance of 10 gallons per head of the whole population, under such circumstances as Mr. Thorn had in view, viz., a voluntary taking of the water; in which case, from 20 to 50 per cent. would, to a moral certainty, abstain from taking it; so that, low as Mr. Thorn's estimate of a domestic supply was, still it would seem that the commissioners, after hearing and weighing all the evidence, deemed it unnecessarily large by near 25 per cent.

The commissioners add, "The quantity required for public purposes will vary, according to the situations and other peculiarities of towns." Now there is no place that I am aware of, where the public and manufacturing demand for water is so great as at Preston, where it is about $\frac{1}{3}$ of the whole. But only half the population of Preston take the water. If the whole should take it for domestic purposes, as would be the case on the plan recommended by the commissioners, this would double the consumption for domestic use, without probably increasing materially that for public and manufacturing use. The

result, then, in Preston, and such places as have the greatest demand for water for public and manufacturing purposes, under the circumstances contemplated by the commissioners, would be that 25 per cent. should be added to the domestic supply to meet that demand. As an average, I see no reason to doubt that this would be very liberal; but to meet extreme cases, and to put the argument in a form that shall be perfectly safe, let us suppose that 50 per cent. be added. The substance of the commissioners' views would then be a recommendation that, where an ample supply can be had, $14\frac{2}{5}$ wine gallons per head shall be provided for domestic use; to which shall be added, for public and manufacturing purposes, a further quantity, varying according to the "situations and other peculiarities of towns," but not exceeding in any case 50 per cent., or such quantity as will make the whole demand per head $21\frac{3}{5}$ gallons.

Now, can any one believe that these royal commissioners, embracing many of high standing as scientific men, would devote the best part of two years to the investigation of facts and evidence relating to this and kindred subjects, and close their labors with such a recommendation as this, if they had before them a particle of evidence, or even ground for the least suspicion, that the consumption of the metropolis was in excess of this amount, at this very time? It is the height of absurdity to suppose any such thing.

If, then, any one feels disposed to cherish a belief in the "obsolete idea" that the inhabitants of London consume 30 gallons per head, or even 20 gallons per head, on an average, it seems to me perfectly reasonable that he should be called upon to sustain his views, and fortify his confidence, with some evidence of a modern date, and of a reliable character, tending to show such a consumption. I believe none such exists.

I may as well say here what I have to say about the consumption of that one other place, which is the last resort of these commissioners, as it was of their predecessors. I feel no disposition to question the accuracy of the amount delivered by the Fairmount works; for, I apprehend, no one familiar with the condition of that city, and the actual state of their streets, will feel any difficulty to account for its disposal. In the first place, the climate of Philadelphia is much hotter than that of Boston; and for all the purposes of luxury and general cleanliness, such as bathing and street-watering, a much larger quantity of water would naturally be required there than here. But, in the second place, the habits, regulations and conditions of the two cities are so different, as fully to account for an immensely larger consumption in Philadelphia than will ever occur here. I understand that Philadelphia, as a whole, may be regarded as *without drains and*

sewers, and *without any system of scavengers.* Animal offal and vegetable refuse is, to a great extent, consumed by swine in the streets; where are also deposited the ordinary collections of dry dirt. The principal, if not the only, means relied upon to carry off this dirt, and the remains of the animal and vegetable refuse which the swine leave unconsumed, is the water-works. A public hydrant is opened, where and when there is any occasion of this kind, and is kept running, till the object be attained, and the nuisance carried off to the ocean; for, there being no drains, there are no gullies to receive this filth, where it might be carried off, underground, by the ordinary operation of drainage. Whatever may be the distance, and whatever the amount, this dirt and refuse must swim, to one river or the other, in a current made by the rains of heaven or by the Fairmount water-works. Now, let any housekeeper reflect a moment,—consider the additional quantity of water which he or she would require to accomplish the removal of nuisances, if no swill or dry dirt barrels were kept,—and, I believe, no difficulty will be found in accounting for all the consumption of water said to be consumed in Philadelphia.

It is, no doubt, putting the case too strong, to say that Philadelphia has *no drains*, and that *all the city refuse* is removed in this way; but, I suppose, it is not too much to say that the city is destitute of a system of drainage at all general, and is destitute of any general, regular and reliable means of removing refuse, except by water.

Now, what fair comparison can be instituted, in the consumption of water, between a city where there is scarcely a street having a sewer and drains, and one where there is scarcely a street without a sewer and drains? and where there is no public provision made for the regular removal of offal and dirt, with one where this is accomplished in the most systematic and regular manner?

In speaking of Philadelphia, I speak of the water district.

On reading the Report of our late commissioners, one can hardly help wondering that not a word is said about consumption of water in New York. As one of them has had so much to do with the Croton works, and must be so familiar with all the details of supply and consumption in that city, one can hardly help feeling surprise that he has refrained from imparting a portion of his knowledge. Perhaps, it was because he wished to deal only in extreme cases; and New York (wasty as she is known to be) has not yet reached the maximum of Philadelphia. But I have a few remarks to offer on this point.

I have before me the Quarterly Report of James A. Coffin, president of the Croton Water Board, for the quarter ending Oct. 31, 1845. It says, "The water was shut off (in October) 13 days, and the quantity used and wasted, during that period, was 10 millions of gal-

lons per day. This I am able to state with tolerable accuracy, for the reason that, when it was shut off at the dam, both reservoirs in the city were full, the upper containing 150 millions, and the lower 20 millions, making together 170 millions of gallons ; and when the water again reached the receiving reservoir, there was remaining, in both, 40 millions of gallons ; which shows that 130 millions of gallons were drawn from them in 13 days, equal to 25 gallons a day for each (person) of a population of 400,000 souls. As the number of water-takers who pay for a supply does not exceed 12,000, which, at 10 persons for a family, amounts to 120,000 consumers, and as the necessary supply for each man, woman and child does not exceed 15 gallons a day, adding to this an allowance for manufactories, steam-engines, &c., $\frac{1}{2}$ million of gallons per day, it will show that 29,900,000 gallons were all that was actually required in the 13 days, instead of 130 millions of gallons." So that here was an out-and-out waste, embracing that used for cleaning streets, &c., of 100,100,000 gallons in 13 days, equal to 7,700,000 gallons per day. Mr. Coffin adds, "During this time, no fire of any consequence occurred, that would require the use of the water."

There are several matters, in this statement, worthy of the most deliberate consideration. It comes from a person officially acquainted with the facts he states, with no motive to misrepresent them, or to deduce false inferences from. Opinions and estimates, formed under the circumstances in which he is placed, are worthy of all confidence.

1st. The first matter worthy of consideration is the enormous waste. Out of 10 millions per day, 7,700,000 are wasted, and only 2,300,000 used. Now, how is water *wasted* in New York, differently from what it is *used* in Philadelphia ? In no manner whatever that I know of. In Philadelphia, almost everybody takes the water, and by that right (I suppose) *uses* it to cleanse the streets. In New York, few take the water, but everybody, without any right but an universal license, *wastes* it to cleanse the streets. In one case it is *use*, and in the other *waste*, the application in both cases being the same. But Boston would never endure to have such floods poured through our streets as nearly deluge those of Philadelphia and New York. The slop and dirt, occasioned by the perpetual currents in the streets of those cities, are nuisances, which, as they would be entirely uncalled for by any public or private convenience, most certainly would not be endured in our streets. We see that this waste, in New York, amounts to about 19 gallons per head per day ; and I apprehend this does not differ much from what is applied in Philadelphia to the same purpose. From this statement, every one can form a judgment how materially

the consumption of water in Boston will differ from that in Philadelphia and New York.

2d. Mr. Coffin's judgment is worthy of consideration as to a domestic supply. He says that it "does not exceed" 15 gallons per head per day; and this for those who take it. If this were averaged upon a population where only $\frac{2}{3}$ took the water, (as is generally the case in water districts,) it would be but 10 gallons per day. Mr. Coffin meant the quantity named as our outside limit,—no doubt, having the truth far within it.

3d. Mr. Coffin's estimate of water consumed for manufacturing purposes is worthy of consideration. I apprehend that no one can doubt that, on the introduction of water into such a place as New York, such manufactories as could profitably use it would, in general, be the first to take it; and that the amount of water consumed by manufactories, would bear a greater proportion to that used for domestic purposes, in the early years of the operation of the works, than in subsequent years. If this be granted, as, I think, it must be, then the water consumed by manufactories in New York, bears a greater proportion to that consumed for domestic purposes *now*, than it will be likely to in future years. Mr. Coffin estimates this consumption for manufacturing purposes at 500,000 gallons per day, and the domestic consumption at 1,800,000 gallons per day; that is, 27.8 per cent., added to the domestic supply, gives the gross consumption for the two objects.

Now, if we assume that $\frac{2}{3}$ of the inhabitants of Boston will take the water, (which there is no reason in the world to suppose will be exceeded in 100 years, *under any system of water-rents*,) then, on Mr. Coffin's basis, 10 gallons per head, for domestic use, + 27.8 per cent., or $2\frac{3}{4}$ gallons, per head, for manufacturing, or, in all, $12\frac{3}{4}$ gallons, will be all that will be required, except for cleansing the streets. Now, if the citizens of Boston are going to consume 19 gallons per head, daily, to deluge our streets, or more than is used in any city of Europe, for all purposes put together, so be it, and they will carry their consumption up to 30 gallons per head per day, and more. But, unless they shall be endowed with a power of endurance beyond anything they have ever manifested, they certainly never will endure the inconvenience which must attend such an enormous waste, and which does attend it in New York and Philadelphia. In the New River district, in London, where there is a bountiful supply, and every opportunity afforded for a liberal use for public purposes, and where, in fact, the streets are kept clean, according to the testimony of Mr. Mylne, (*Quest.* 5716,) less than 6 per cent. of the whole consumption is used for "the larger consumers and street-watering." If the whole of this

were used for street-watering, it would amount to less than 1 wine gallon per head, per day, of the whole population. Now, I apprehend that the habits of the city of Boston, its climate, and its system of cleanliness, approach much more nearly to those of London than to New York or Philadelphia. Still we may double, treble, and even quadruple, the quantity used for this purpose in London, and still our consumption, on the data given by Mr. Coffin, will scarcely exceed one half the amount which our commissioners think we shall want.

If it should strike any one that the London consumption for watering streets is very small, he must reflect that the district is exceedingly compact; and that, there, as here, there will be an average of five to six months in every year in which no water, or nearly none, will be used for this purpose.

The reader cannot be more sensible than I am of the very desultory manner in which I am taking up these various topics. In fact I felt myself unable to bring these various topics into any appropriate connection with any leading point of discussion between Charles River and Long Pond.

But in what I may have further to say on this Report, I shall endeavor to discuss the views and statements made therein in connection with one of the three following points, viz.: *The quality of the waters in Charles River and Long Pond; the quantity of the waters in those sources; and the modes and expenses of procuring a supply from each.*

Before, however, dismissing the Spot Pond plan, I wish to express my views of the very unfair manner in which I conceive these commissioners have treated Mystic Pond. It is not at all to be disguised that the advocates of Spot Pond have always and uniformly looked to a future augmentation of supply by resort to Mystic Pond. It is only in connection with Spot Pond, that these commissioners were at all concerned with Mystic Pond; for nobody thinks of taking that except as an auxiliary supply.

Of Spot Pond, of Long Pond, and of Charles River, the commissioners took at least *two* samples; of Mystic Pond they took but *one*. Of the others, the samples taken appear to have been taken for the purpose of ascertaining the *true* quality of the water; that of Mystic Pond was taken to ascertain a *false* quality of the water; that is, "to ascertain how far the tide affected the quality of the water of the pond." And what did they find? Just what they probably expected to find, and what, if they had tasted, they might have known that they had found, viz., that "it was, in fact, dilute sea water." And this was the *only* sample.

Now no commissioner, or citizen, who ever looked to Mystic Pond

for a supply, was so simple as to think of that source except on condition of the ocean being excluded. The idea is too ridiculous to suppose that this pond was to be resorted to while salt water had access to it. Why, then, did not these commissioners take one or more *fair* samples of *Mystic pond* water for analysis, and let folks know what that pond now contains, and what it will *exclusively* contain, if ever resorted to as a source, instead of confining their inquiries to a jug full of "dilute sea-water?"

I propose, then, 1st, to consider what these commissioners say in regard to the *quality of the waters of Charles River and Long Pond.*

At the outset, the commissioners (p. 95,) set forth that "Mr. Silliman had no knowledge whatever of the particular sources of the several samples of water which he analyzed." This statement is made *probably*, as it has been publicly referred to *certainly*, for the purpose of securing confidence in the results of Mr. Silliman's analysis. But these results are not entitled to any *peculiar* confidence on this ground. Precisely the same precautions were taken when Dr. Jackson analyzed for Colonel Baldwin in 1834, and for Mr. Eddy subsequently; and when Mr. Hayes analyzed for the commissioners of 1837. No freedom from prejudice from this cause, therefore, can be claimed for Mr. Silliman, that may not with the same propriety be claimed for Messrs. Jackson and Hayes.

Is there any other reason why more confidence should be placed in these results of Mr. Silliman than in those of Dr. Jackson and Mr. Hayes? I suppose I hazard nothing in saying that the reverse is decidedly true. Without derogating an iota from the just merits of Mr. Silliman, I apprehend neither he nor his true friends would feel in the least degree hurt by his being placed in a rank far below either of those accomplished practical chemists. Mr. Silliman is quite a young man, starting in a scientific career under the most favorable auspices, to which I have no doubt he will do credit. But Messrs. Jackson and Hayes are much more advanced in life, of much more practical experience, and have been in the front rank of their profession for fifteen years at least.

What, then, is the most that ought to be claimed for these results? Certainly the most is that they should go into the mass with other results from which an average may be obtained.

I say this is the most that can be claimed. There are, however, some circumstances which would reasonably lead one to grant something less than this; especially in comparison with the results obtained by Mr. Hayes. The commissioners say, (p. 101), "that the analyses (of Mr. Silliman) were made on a scale of ample magnitude to insure correct results." And Mr. Silliman gives us an idea of this

scale (p. xiv. Appendix), where he says, "a carefully measured standard gallon of each sample was taken." He also says these samples were received 12th September, and his Report is dated 29th October; so that his experiments and his Report occupied 47 days. Now is the quantity here stated, and the time here given to the examination, on a scale sufficient to "insure correct results?" I am not a correct judge; but they certainly fall far short of the scale adopted by Mr. Hayes. He informs me that "the experiments performed here, [meaning those performed by him for the commissoners of 1837,] had reference to a general scientific knowledge of the waters, as well as an accurate determination of particular characters, and I had all the compounds contained in them, in quantities abundantly large. 22 *thousand* pounds (11 net tons) of peaty water were evaporated for the general constituents, and *eleven months* in time were given to the examinations." How insignificant do the scale of Mr. Silliman, and the time employed by him, appear in comparison with this!

In this connection I beg leave to state a circumstance not generally known.

If any one will refer to the introductory remarks of Mr. Hayes, in his Report to the commissioners of 1837, and printed at p. 90 of their Report, he will notice that this Report of Mr. Hayes was given before he had completed his observations; and he stated that, "I defer to a future time a more detailed account of their chemical qualities." When Mr. Hayes had finished his observations, he made out a full detailed report as here promised, and sent it to the commissioners. It was quite long, elaborate, and full. As he expected it would be printed, he made no copy of it. It, however, never was printed, and no public notice whatever was taken of it. What appears remarkable is, that it cannot now be found. I have made inquiries for it in vain; and Mr. Eliot, who was then mayor, and under whose auspices these investigations were performed, and the documents printed, recently assured me of his ignorance that a more "elaborate analysis had ever been made by Mr. Hayes than that which is annexed to the report of 1837; *I certainly never saw it.*"

Now, what would have been the decision of this question had this document, prepared with immense labor, and probably at considerable expense to the city, for the sole purpose of enabling the commissioners and the public to make a wise and judicious selection of a source of supply, been printed, as it was designed to be, no one can now tell. But we may tolerably well guess what source the results in that document indicated as the best, from the fact that Mr. Hayes is known to entertain a preference for Charles River.

But to return to the subject. The most that can fairly be claimed for Mr. Silliman's results, is, that they are worthy to go in with those of Mr. Hayes and Dr. Jackson, for the purpose of obtaining an average. By referring to p. 9 of Report of 1837, and p. 104, of commissioners of 1845, the following result is obtained, viz.:

			L. Pond.	Ch. River.
Earthy Matter found by Dr. Jackson,	1834		6.	4.
" " " Mr. Hayes,	1837		3.03	3.32
" " " Mr. Silliman,	1845		1.85	3.40
			10.88	10.72
Average,			3.63	3.57

Hence it appears that the average of the analyses is in favor of Charles River; which would be increased if the analysis of Dr. Jackson of Long Pond water last winter should be included, or an average of the 2 samples of each analyzed by Mr. Silliman. Such, too, is the result, although every person acquainted with the state of Long Pond and Charles River, at the time these last samples were taken, cannot but be aware that it was peculiarly favorable for the pond, and not so for the river.

It is a little curious that, though the commissioners consider the Long Pond water as more free from iron than Charles River, the *only* sample out of four taken from Lond Pond and Charles River, which, on separating its component parts, afforded traces of iron, was taken from Long Pond, (p. xxii. Appendix.) And I do not see anything more suspicious in either of the Charles River specimens than is afforded by the statement that No. 5 (the best sample of Long Pond) " became decidedly *ferruginous* as it evaporated." If this language be not *irony*, it gives pretty strong indications of iron.

I will advert to but one other circumstance affecting the character of these waters, as developed by this analysis. I refer to their action upon lead. The commissioners give the preference on this ground to the water of Long Pond; but, as I think, contrary to the evidence of facts and fair deductions. Mr. Silliman says, (p. xi. and xii. Appendix,) " Since it has been supposed that the presence of a considerable quantity of this (carbonic acid) gas in a water was one principal source of the corrosion of leaden pipes used for the conveyance of water, it seemed to me a question of some practical interest to determine, as nearly as could be, the actual amount of this gas in the several specimens in hand."

Here seems to be an acquiescence on the part of Mr. Silliman in a general doctrine on this subject, and the acknowledgment of the

practical interest that attended the experiments. An *a priori* expectation is raised that the samples of water which should develop the greatest quantity of this gas, would be likely most to corrode lead, and be objectionable to a like extent. Now, after very nice and careful experiments, Mr. Silliman finds more than twice as much of this gas in the Long Pond water than in the water of Charles River.

Now, if there be any ground for the supposition that the presence of this gas does corrode lead, which seems to be fully admitted by Mr. Silliman, why is it not fair to deduce a preference for that which has but little over one which has twice as much ?

It is worth while to trace Mr. Silliman, and see how this doctrine is brought into doubt. After trying a strip of lead in each specimen of the waters, and stating the results, he says, (p. xxiii. Appendix,) " We see also that the water which contains the most carbonic acid, (No. 2,) and the most but one of solid matter, had no effect whatever on the lead.

" *These facts certainly appear anomalous*, and lead to the conclusion that we are yet without the means of establishing any general rule by which we may judge whether any given water will act upon lead."

These facts *appeared* to Mr. Silliman anomalous, and go to bring into doubt the rule in regard to the action of this acid or gas upon lead. He does not seem to have suspected the inadequacy or inaccuracy of his experiments. And if we take from his eyes the bandage under which he worked, and show him that this very No. 2 does notoriously and beyond dispute act upon lead, his faith in the rule may, perhaps, be restored.

This No. 2 was Croton water, and contained much more of the objectionable gas than even Long Pond. And by reference to p. 146, *Tower's Illustrations of the Croton Water-Works*, we find it stated that " Dr. Chilton recently inspected the Croton water drawn from the lead pipe by which it is introduced into No. 421, Pearl street, in this city, (New York,) and found the water evidently affected by the lead. He also obtained similar results in several other instances." In consequence of this action of the Croton water upon lead, it is stated that the city authorities, in supplying the public buildings, do not use lead pipes, but pipes lined with tin or composition. And the same is strongly recommended to the citizens.

Now, as Mr. Silliman no doubt knew these facts in regard to Croton water, had he worked with his eyes open, he would have saved himself the mortification of deducing conclusions from his experiments at variance with them. As the Croton water is highly charged

with this deleterious gas, and does act upon the lead of the pipes in New York, a fair conclusion is, that the water of Long Pond, which is also highly charged with the same — much higher than that of Charles River — will also act upon the lead of the pipes in Boston. And as the city authorities there have repudiated the use of lead pipes on this account, so it will probably be here.

As I have no pretension to chemical knowledge, I will here dismiss this analysis. I have, however, abundant reason for believing that in many respects its deductions are fallacious, and its reasonings erroneous; on the whole, that it is not worthy of confidence.

The commissioners have said considerable of *animalcules*, and have published the views of others. It would seem as if they found them in about like number in all these specimens, but most in Charles River. But much of what is said by them and others I am not able to appreciate, because it in only a few instances is stated whether the animalcules were visible to the naked eye or only visible by aid of glasses. This is an important distinction; and it is only in regard to those visible to the naked eye that I have ever attached any importance. And say what commissioners may, and harden their own and the public sense as they can, to an indifference to the presence of these creatures, they never can, and they never will, induce among the people a free and copious use of any water as a drink, which shall ordinarily, and as matter of course, exhibit these creatures to the naked eye. Wherever and whenever such is the case, the people will become swift converts to one of two doctrines, viz., that the system requires but little inward moisture, or that "a little brandy is better than too much cold water." The paupers of St. Giles and Shoreditch repudiate such drink; and they prove that, though driven to extremities, human nature is not extinct in them.

Now, I apprehend that, in spite of everything that has been or can be said on this subject, it is a settled fact, that *running* water is much less liable to exhibit this nuisance to the naked eye than *still* water — common *river* water, than *pond* water. I apprehend an appeal to experience will settle this. I apprehend that if any one will do as I have done during the past year, he will find nearly the same facts. I have examined near 20 samples of Charles River water, taken at different times, from Watertown, Waltham, and Newton Lower Falls, and have not found a single sample containing animalcules visible to the naked eye. I have inspected nearly or quite as many specimens of Long Pond water during the same time, and do not remember more than two samples in which these creatures were not visible to the naked eye. In this way I have settled the point in my own mind; and in this way I think most persons might do the same.

With these remarks I close what I have to say upon the quality of the two waters.

A few words now upon the *quantity* in those two sources.

The commissioners of 1845 have estimated the flow from Long Pond considerably higher than did their predecessors of 1844. The latter supposed that the pond could not be relied upon to deliver at Corey's Hill much more than 7 millions gallons per day; while the former think 10 millions may be depended upon.

I do not know as it is worth while to advert farther to the very uncertain and unsatisfactory nature of the evidence and reasoning by which this additional quantity is relied upon. But one effect of this estimate is very obvious. While the mass of our citizens are pleased at the prospect of obtaining such an exhaustless supply, the proprietors of mills and wharves on streams below are estimating their damages. And if we have reason to congratulate ourselves that our contemplated source will be more copious than we before anticipated, we may feel pretty well assured that the amount claimed of us for damages will be advanced in an equal proportion at least. And these extra claims will be advanced, sustained by this very Report, and be paid, long before we shall know whether there is any good foundation for them; and the result may be, after all, that we shall pay for 10 millions per day, and get but 7 millions.

Though these commissioners think they have found much more water in Long Pond than their predecessors, they appear to have found less in Charles River. They did not find *one half* so much at the race above Newton Upper Falls, as has been hitherto supposed to flow by Waltham Factories in the driest times. On one single day they found less water in Charles River at the place of guaging than the estimated average daily yield of Long Pond. Still, as by their account they would not claim any preëminence for Long Pond in point of *quantity*, I deem it important to allude to their estimates, only to notice *two* remarkable circumstances.

1st. On p. 47, the commissioners say, —

"We annex the following table of the average flow of water in Charles River at the place above stated, by the mean of several sets of observations taken each day. They generally commenced on each morning, before the starting of the mills below, and when by the accumulation of the previous night, the back water came so high as to retard, in some measure, the velocity of flow through the sluice, and to increase its ordinary depth. From this time the experiments were made at intervals through the day, terminating about the time when the mills were again stopped."

Now, to give some idea how much the back water actually retard-

ed the velocity of the water through the sluice, I annex the following minutes of these commissioners, for three days:

Date.	Time of Observation. h. m.	Time of floating 20 rods. m. sec.
Sept. 22,	5 35 A. M.	25 10
	9 5 "	9 01
	12 10 "	8 14
	3 15 "	7 02
	5 55 "	6
" 23,	6 "	13 17
	9 "	6 26
	12 10 "	5 28
	3 "	5 35
	5 "	5 30
" 24,	5 55 "	11 3
	9 5 "	6 46
	12 15 "	5 24
	3 05 "	5 13
	6 10 "	4 52

I insert this table just as it has been furnished me. But a slight deviation is noticeable in time, in one or two instances, from the statements in the table of the commissioners; but they are of no moment in regard to the point I have in view. It will be seen that the back water was such that at the *first* measurement *before* or near the time of the mills getting into operation, the velocity was less than 1 rod per minute, and at the 2d measurement it was more than 2 rods per minute, and the velocity kept increasing all day. Just about the same ratio is noticeable between the velocities, at the 1st and 2d measurements, on the succeeding days. From these data it appears to be inferable, if it be not demonstrated, that, owing to the height of the dam below this sluice, the water at and above it was rendered in the night time nearly or quite stagnant.

Now, in ordinary cases, this would not be important in guaging the whole contents of a stream; because what was kept back at one time would come forward at another. But it is not so at this point of Charles River; for if the water be kept back at this point it never comes forward, but finds its way through Mother-Brook to Neponset River. From the data above given, it is certainly rendered probable that some (perhaps a large quantity of) water which should have gone down Charles River, was diverted to Neponset.

And I have it also from several persons interested in the water power at the Lower Falls, that during the dry period of the last year, the dam at the Upper Falls was raised to an unlawful height by means of flush boards; and that, in point of fact, water belonging to

them was by this means lost to them to a greater or less extent. If this were so, as is avered, it is a circumstance that could hardly have been kept from the knowledge of the commissioners; and if it was known to them, can there be any good reason why the fact should not be named?

2d. But if the commissioners lay themselves open to the charge of having concealed an important fact connected with the guage, what shall be said for them in *omitting entirely* all notice of the accessions to the stream below. All estimates of all commissioners have been made on the basis of taking the water from Watertown. Between the race, where the water was guaged, and the dam at Watertown the following brooks enter the river, viz.: Garfield's Brook, Rice and Parker's Brook, Stony Brook, Waltham Brook, and just below the Watertown dam, but so near as to be available, the Baptist Pond Brook. Now all these brooks are supposed to add at least $\frac{1}{5}$, and probably $\frac{1}{4}$, to the volume of the river. What, then, can be an apology for the commissioners in omitting all mention of these additional supplies? I certainly see none. I will here dismiss the subject of quantity.

I come now to the consideration of the structures, and the estimates for bringing in these waters. This is by far the most important part; and I feel as if an apology were due to the reader for deferring it so long. But the Report is so full of statements inviting animadversion, that I can assure the reader I have refrained with some difficulty from introducing several topics which I should certainly have touched upon, but for a regard to his patience.

As to the structure from Long Pond to Corey's Hill, the commissioners have adopted identically the same conduit, and nearly the same pipes, as were adopted by the commissioners of 1844. I have little more to say on this topic, but to state that these commissioners have provided for giving this structure additional support in certain places; which (as far as it goes) is a great improvement. It is not, however, yet satisfactory; and I believe, if the plan be adopted, it will be found necessary and expedient to give it still greater strength, or live under a constant apprehension of failure. Especially do I believe this will be required in passing through the mud of the first few miles.

But in the reservoir on Corey's Hill, and in its connection and arrangement with the reservoir on Beacon Hill, there is considerable departure from the plan of 1844; and it merits notice.

On pp. 82 and 83 the commissioners say, "It is proposed to make the waste weir of this reservoir (at Corey's Hill) at a level with the top of the conduit, or say 121½ feet above tide level. . . This water

will, at times, fall a little below the level of the waste, but with so large a reservoir as is contemplated, this will be for very short periods. And the variation in height will generally be but a few inches." . . . "The water at the Corey's Hill reservoir may be taken at a constant elevation of 121 feet above the marsh level, and usually at 121½ feet." . . . "*The city reservoir has been assumed at 112 feet above tide. This leaves a fall from Corey's Hill reservoir of 9½ feet, as the greatest, and 9 feet, as the least.*" . . . "The waste weir of the Beacon Hill resorvoir should be placed on a level with that of Corey's Hill, or 121½ feet above tide." . . . "In order to supply the high district about the State House, this depression (i. e., the depression of the water in the Beacon Hill reservoir, or, practically, its bottom) must have a limit." And immediately below, "a fall of 8 feet is taken for this limit."

In making this quotation I have omitted nothing which limits or qualifies the language quoted.

I understand it here to be stated that the top of the Corey's Hill reservoir, and the top of the Beacon Hill reservoir, are to be on the same level, viz., 121½ feet above tide level. And I understand that the water in the Beacon Hill reservoir is not to be drawn down more than 8 feet, and of course it may be practically considered as only 8 feet deep. This being, as it seems to me, clearly the meaning, as it is nearly in the very words, of the Report, I would ask what is the meaning of the sentence I have put in italics? It cannot be true, nor near the truth. In a proper sense there is no fall between the reservoirs. The only fall is the difference in which the reservoirs are drawn down. In this sense, instead of the greatest fall being 9½ feet, it can of course never exceed 8; and instead of the least fall being 9 feet, it is just nothing at all. I do not see how, under the most favorable circumstances, an average of more than 4 feet during the 24 hours could be claimed; and how a statement so gratuitous could have escaped the commissioners I am at a loss to understand.

The commissioners propose to bring the water from Corey's Hill to Beacon Hill by two pipes of 34 inches diameter. They seem to have proposed them as having a capacity 20 per cent. larger than necessary if a uniform and constant flow could be maintained; and it is reasonable to suppose that they considered them capable of furnishing, even under the disadvantage of an inconstant and unequal flow, 25 per cent. more than 7½ millions per day, in dry weather. But by the formula of Prony, these two pipes will, with an average fall of 4 feet, and supposing the flow constant and equal, deliver less than 9¼ millions gallons in 24 hours. This is less than sufficient

to supply 25 per cent. over $7\frac{1}{2}$ millions, demanded in dry weather; to say nothing of the necessary allowance for incrustation in the pipes, and for the 20 per cent. extra capacity required by the unequal flow.

Again, on p. 81, the commissioners state that they propose the reservoir on Corey's Hill shall cover 8 acres, "with a depth of 25 feet." . . . "The reservoir will contain 53,000,000 gallons." It must be allowed that this extent and depth is worthy of the city to be supplied. A week's supply, at $7\frac{1}{2}$ millions a day, is treasured up, to serve in case of accidents. But, alas, these waters are in good degree the waters of Tantalus. They can never get to Boston by the apparatus provided. For, as the bottom of the Beacon Hill reservoir, into which the pipes leading from Corey's Hill are to empty, is to be but 8 feet below the surface of the Beacon Hill reservoir, which is to be on a level with the Corey's Hill reservoir, it follows that the Corey's Hill reservoir cannot be drawn down more than 8 feet,— a little less than $\frac{1}{3}$ of its depth, 25 feet. So that, instead of a week's supply, there can be but about 3 days' supply available; while a stagnant stratum of 17 feet is to lie there unmoved from year's end to year's end.

Now, if there be any good reason to construct a reservoir 25 feet deep, (a depth without example, I apprehend, unless it be New York,) and to be drawn down only 8 feet, it has not occurred to me.

I come now to consider the structure for conveying water from Charles River to the reservoir on Corey's Hill; and the estimates of investment and current expense of pumping.

The general plan is to convey the water from the dam at Watertown in a conduit like the one proposed in the Long Pond scheme, to the foot of a hill in Brighton; then to force it into a reservoir 140 feet high; thence to convey it 8000 feet to Corey's Hill reservoir, by two 24 inch pipes, and discharge at a height of 121 feet.

I do not see any objection to the mode of conveying the water to the engine-house, nor to the location of that house and the reservoir. But the most cursory reader can hardly fail to notice the great fall that is contemplated between this reservoir and that of Corey's Hill, viz., 19 feet. And the question forces itself upon one, why should a perpetual expense be incurred to throw up all this water to a height of 140, in order that it may fall 19, feet, in passing about $1\frac{1}{3}$ miles, while, in passing from Corey's Hill to Boston, a distance of near 4 miles, a fall of but 4 feet is provided?

A suspicion of extravagance and waste is at once excited, and the matter needs but slight examination to have it confirmed.

Although the water is to be raised 140 feet, and to be delivered at

a height of 121 feet, (see p. 36,) a difference of 19 feet, yet the commissioners say, "allowing for considerable loss of head, that will occur, mostly, in discharging the water into a small summit reservoir, there may be assumed to be about 15 feet effective head on the pipes, to carry the water to Corey's Hill."

Now, although it may be expedient that the head upon the pipes shall vary, according as the reservoirs shall be full or empty, to the extent of 8 feet, so that the average fall shall be 4 feet less than from the top of the reservoir, yet this should not be considered *loss.* For, in the degree that the head is diminished, the load upon the pumps is diminished in same degree. If the water be forced in, as I apprehend it should be, at the bottom of reservoir at one end, and be drawn out at bottom at the other end, it appears too plain for argument, or illustration even, that the load upon the pumps varies with the "effective head;" and if, as the commissioners in this case say, that is to be but 15 feet, it follows that the column upon the engine will be but 136, instead of 140, feet. But as the engines are supposed to work under an average pressure of 140 feet, (varying from 136 to 144 feet,) there is provided a head of 19 feet, which should be "effective." It thence appears that the commissioners have added to the labor of the engines 4 feet in 140 elevation, or near 3 per cent. of the whole work, for which they contemplate no advantage whatever; and this, not to any considerable extent in original outlay, but in current expense, to last forever.

Now, as this current expense is to be a perpetual charge, it should have been an important point of study and examination with the commissioners to impose upon the engine the least amount of labor, consistent with an adequate transmission of the water from the summit reservoir to the one on Corey's Hill. In this view, not feet, but inches, and even barley-corns, in elevation, acquire importance.

It becomes important, then, to inquire how the requisite quantity of water can be conveyed from the summit reservoir to Corey's Hill, so as to impose the least labor upon the engines in raising it.

I do not know that a more available plan of a reservoir can be devised than the one which appears to be contemplated by the commissioners, viz., 8 feet deep. If the *bottom* of this reservoir be placed on a level with the *top* of that at Corey's Hill, which is to be 121 feet above the tide, and if it be filled every day and emptied every night, the average effective head will be 4 feet, and the engines will work under the pressure of a column varying in height from 121 to 129 feet, or an average of 125 feet.

The commissioners appear to me to attach too much importance to having *two* pipes between these reservoirs. If they were to pass

under navigable or other water, or through locations not easily accessible from any cause, there might be reason for adopting the precaution of double pipes. But in a line everywhere accessible, as this is, it seems to be an idle precaution. For on inquiry of the agent of the Boston Aqueduct Company, where only one main comes from the pond to the city, I learn that a breach in the main is very readily repaired. To take out one piece of pipe and insert another is usually accomplished in less than 6 hours; and it is not obvious why more time should be consumed on the proposed line than this. The circumstances must be peculiarly adverse, which can ever occasion the stopping of the current during 24 consecutive hours. I cannot but regard it as an entirely useless expense to provide *two* pipes.

What, then, is the *size* and *cost* of one pipe, that, under a head of 4 feet, will convey $7\frac{1}{2}$ millions gallons from the summit reservoir to Corey's Hill? *I say* $7\frac{1}{2}$ *millions*, because, as the head can be increased at any time to 8 feet by working the pumps longer, or by using the spare power during a portion of the day, I apprehend no one will question that it will be good economy to provide the extra quantity needed in warm weather in this way rather than by enlarged pipes. In fact, the extra quantity must be provided in this way.

On examination, I find that a single pipe of 34 inches diameter, by a head of 4 feet, will discharge, at the distance of 8000 feet, almost exactly $7\frac{1}{2}$ millions gallons per day, according to Prony's formula. What, then, is the difference in cost of 2 pipes of 24 inches, as proposed by the commissioners, and one of 34 inches, proposed as a substitute?

16,000 feet, 24 inches, at	$7,43 (p. 54), is	$118,880
8,000 feet, 34 inches, at	11,60 (p. 87,) is	92,800
	Difference,	26,080

We have thus relieved the engines of a pressure equal to a column of 15 feet, i. e., the difference between 140 and 125 feet; and construction account of 26,080 dollars.

I will here remark, that I am reviewing the labors and plans of others. It is therefore proper to trace the effect of any waste that is noticed. I feel, however, far from confident, that it will not be the true economy to pump the water as high as 140 feet. This will enable it to reach Corey's Hill as high as 136 feet. With such a head, water could readily be distributed through the city without the intervention of another reservoir.

The next matter for examination is the expenses for pumps and appurtenances, and pumping.

This is the most important matter of inquiry; and into what I now propose to say I wish most respectfully to invite the severest scrutiny. If the points I propose to establish are not sustained by facts and substantial reasons, let them be rebutted, and their fallacy be pointed out. But if they shall be well and truly established, in a manner and by facts and reasons which cannot be gainsaid, controverted, or resisted, I hope the reader will fairly and candidly weigh the results, just as he would if the matter were one of individual concernment, and the responsibility were entirely on his own shoulders, instead of being divided with 115,000 inhabitants.

No one at all conversant with the subject can, I think, read the report of the commissioners on the subject of pumping, without being impressed with the small amount of their own knowledge, and the sterility of the sources to which they look for more. They do not seem to be familiar with a pump or an engine. Their references are mainly to obsolete papers, or irrelevant examples of work; so that there would seem to be reason for the remark made in the report of the water committee of the legislature: "And we would state here, that the commissioners have more confidence in the accuracy of their estimate relative to the Long Pond source, than they have of the Charles River source."

Well might the commissioners, and well may we, distrust their estimates on this point, though in a way and for reasons entirely different from those implied and conveyed.

In the dearth of information and materials by which the commissioners seem to have been surrounded, the letter of Mr. Wicksteed to Mr. Eddy was quite a windfall. It was new, it was from a first rate authority, and was directly to the point. The commissioners say, (p. 45,) "Mr. Wicksteed's estimate must be regarded as affording the most definite and reliable information at command, and will therefore be taken as a basis." They therefore did settle down upon the basis of Mr. Wicksteed's letter; that was the document, though "not written exactly under professional responsibility" on which they relied "as affording the most definite and reliable information." The errors and oversights which they pretend to find and correct will be noticed afterwards.

This letter, then, of Mr. Wicksteed, acquires great importance. It is made the basis of an inquiry involving millions, and it should be looked at critically. I propose to insert the letter; and as I was knowing to the circumstances under which it was obtained, I will state them. In the early stages of the opposition to the Water Act of 1845, Mr. Eddy asked my opinion of the expediency of obtaining Mr. Wicksteed's views of the advantages of pumping, in order to

give the public full and accurate information on the subject, and perhaps to induce a selection of Charles River, if the act were accepted. I did not hesitate to approve the suggestion, and urged Mr. Eddy to write at once. This he did by the steamer of April 1st, (his letter being dated March 29;) and Mr. Wicksteed's answer is dated 16th April, or 19 days only after the date of Mr. Eddy's.

Engineer's Office, Old Ford, near London, April 16th, 1845.

Sir, — I have received your favor, dated the 29th ult., and, in reply, beg leave to say that I have much pleasure in affording you the information you require, as I am a great advocate for the extension of water-works, and am confident that the best plan to be pursued is to give large quantities, under great pressure, by the most economical means; as that which produces a good dividend to the capitalist and a low rate to the consumer, will most probably generally be preferred to an expensive plan, however imposing and costly works may be to the eye; which, however, under such circumstances, must not be directed towards your pocket.

After 6 or 7 years' experience of the economy of the expansive pumping engine, I am induced to recommend it most strongly. Since its erection at Old Ford, in 1838, another has been erected at Southwark, and I have now no less than 5 large engines making for different works, while plans are preparing for 4 more, and for the conversion of 3 old Boulton and Watt and Mandslay engines into expansive engines. These are all for water-works, and will prove that prejudice, if not destroyed, is giving way.

The cost of raising water at the East London Water-Works, in 1830, before my improvements were introduced, and the cost of raising it in 1844, since the improvements have been made, will show you the practical results obtained.

Cost of raising 1000 imperial barrels (361 lbs. weight per barrel) to a height of 100 feet, in 1830 and in 1344:

	1830. s. d.	1844. s. d.
Coals	1 1.718	0 3.917
Stores	0 1.177	0 0.920
Labor	0 3.202	0 2.938
Repairs of machinery and building	0 5.272	0 1.655
Total	1 11.369 or 1s. 11½d.	0 9.410 or 9½d.

	s. d.
1830	1 11½
1844	0 9½
Saving	1 2

1s. 11½d. : 100 : : 9½d. : 40 — showing a saving of 60 per cent.

In 1844, the quantity of water raised was 80,072,223 imperial barrels. The coals used were equal to 2312 tons, 18 cwt. 2 qr. The cost, delivered in the bin, was 11s. 3d. per ton.

In 1830, the quantity of water raised was 51,519,290 imperial barrels. The coals used were 3758 tons, 17 cwt. 0 qr. The cost was 16s. $9\frac{4}{5}$d. per ton.

You propose to bring a supply of water equal to $2\frac{1}{2}$ millions of gallons per diem, (at 8 lbs. each gallon,) which is equal to 2 millions imperial gallons, in round numbers, or, to be exact, 1,994,614, a distance of 7 miles in pipes.

Supposing this quantity, say 2,000,000 imperial gallons, to be delivered in 12 hours, through a main 30 inches in diameter, and 7 miles long, it will require a column of 20 feet to overcome the friction of the water passing through the main; this added to your 120 will make 140. But it is well to have plenty of head, and I will assume the water at the source to be raised 150 feet.

Water to be raised $\frac{445 \text{ cub. ft. pr. min. x } 150 \text{ ft.}}{528} = 126\frac{1}{2}$ horse power.

Suppose your engine to make 8 strokes per minute, at the maximum, then your plunger pole or pump must, at 10 feet length of stroke, be 32 inches diameter; the load upon your pump will be equal to 52,359 pounds, the diameter of your cylinder will be 75 inches, and the stroke 10 feet; the coals required will be equal to 36 cwt. per diem.

ESTIMATE OF COST.

	£ s. d.
Engine and boilers	7,500 0 0
Engine house, boiler house and chimney	3,700 0 0
Stand pipe 150 feet high, and foundation	3,300 0 0
Reservoirs and filter beds	7,000 0 0
Sundry works	2,000 0 0
Contingencies, including Engineering	4,700 0 0
	28,200 0 0
Suppose a spare engine and its buildings and contingencies	12,300 0 0
	40,500 0 0
Seven miles 30 inches main, 5600 tons, at £10	56,000 0 0
Cost of laying 12,320 yards, at 15s. 6d.	9,548 0 0
Contingencies, including engineering	6,452 0 0
	72,000 0 0
Total cost of bringing water to the town, at an elevation of 150 ft. at the town	40,500 0 0
	112,500 0 0

ANNUAL COST.

	£	s. d.
Coals, 657 tons, at 12s.	394	4 0
Two engine men, 42s. each, and two stokers, 30s. each	374	8 0
Stores, including oil, tallow, hemp, &c.	150	0 0
Repairs of machinery and buildings	270	0 0
Foreman, two guineas per week	109	4 0
	1297	16 0

You will hardly require an expression of my opinion as to the Long Pond project, which, you tell me, is to cost £1,000,000, after what I have given you; but this is the way I should propose to settle the question:

Interest upon cost of Long Pond scheme, at 5 per cent	£50,000
Interest upon capital for Charles River scheme	5,625
Annual cost	1,298
	£6,923

I think the two amounts, £50,000 and £6,923, ought to settle the question — with me it certainly does — in favor of the Charles River scheme.

I have pleasure in sending you two or three reports and specifications, and shall be glad to hear that the information I have given you has been of service to you.

Beyond the desire to advance water-works, I feel some interest in Boston, as I had a brother who resided there for some years, about 22 years ago.

I am, sir,

Your obedient servant,

THOS. WICKSTEED.

R. H. Eddy, Esq., Civil Engineer.

The first reflection which occurs upon reading this letter, and noticing dates, is, that it was *hastily* prepared. It implies an almost incredible accuracy of knowledge and facility of applying it, to escape "errors and oversights."

The second reflection is, that, as there was ample time for the commissioners to consult Mr. Wicksteed, it was a great departure from the comity due from one professional person to another, to seize upon, and spread before the world, a series of errors and oversights, without giving *him* an opportunity to explain, or *themselves* an opportunity of ascertaining whether they were real or only apparent.

No gentleman, it seems to me, can regard this measure in any other light than as extraordinary. The importance which would have attached to an understanding with Mr. Wicksteed in regard to apparent discrepancies, can hardly be overestimated; and how sadly the character of the commissioners, as men, and the results of their labors, as engineers, have been compromised by their unauthorized assumptions, will appear from Mr. Wicksteed's remarks, subjoined.

By the steamer of December 1, after having hastily perused the Report of the water commissioners, I took occasion to write to Mr. Wicksteed, stating briefly the supposed errors and oversights noticed by the commissioners, in his letter to Mr. Eddy. It appears that Mr. Rogers wrote to Mr. Wicksteed by the same packet — stating, in substance, that our water question was probably settled by the new Report.

By the steamer of December 16, I sent Mr. Wicksteed a copy of the Report itself. On the 2d January, *before* this copy had come to hand, Mr. Wicksteed wrote to me, acknowledging the receipt of my letter, and that of Mr. Rogers; and, as he supposed the question settled, he thought it inexpedient to notice the matter further. It seems, however, that he changed his mind, when he received the Report; and the following letter has been received by Mr. Rogers.

This explanation seems to be called for, by Mr. Wicksteed's allusions to me.

Old Ford, February 3, 1846.

Dear Sir, — I had considered that my letter to Mr. Wilkins, of the 2d January, would have ended the correspondence, so far as I was concerned; but having since been favored with a copy of the Report of the water commissioners, published under the authority of the municipal government of your city, in which my statements are frequently referred to, I find it necessary to address a few lines to you, in self-defence.

You will allow me to commence by stating that my introduction to the question of supplying the city of Boston, arose from an application to give my opinion as to which of two projects, then before the Boston public, it would be best for the city authorities to adopt. In reply to this application, I gave, as a matter of courtesy and of friendly feeling, the letter which Mr. Eddy published; and I must state, that I felt some surprise when I found that such a letter had been made use of as professional Report, and that all parties concerned seemed to consider me as a firmly bound ally to one of the belligerent powers in the local war, which the agitation of so important a question has naturally produced.

As before stated, I had considered that, in my letter of January 2, I had taken leave of the affair, and upon that impression I shall still act, confining any remarks I may now make to those portions of the City Report which directly concern data or opinions to which I have pledged myself; but even upon this point I should have abstained from further interference, had not the document in question borne upon the face of it the *imprimatur* of one of the first cities in the United States.

1. In the statement on p. 34, reference is made to two *letters* of mine, published by the Institution of Civil Engineers; and facts resting, as therein expressly stated, upon the authority of others, are quoted from them, but no mention is made of my elaborate Report and Tables, published four years afterwards, (by John Weale, 59 High Holborn, London, 1841,) in which the results of *my own* experiments, or rather of my experience, are stated in detail. This appears to me to be a superficial, if not an unfair, mode of inquiry.

Why should my opinions, founded upon the assumption that facts stated by others were true, be preferred to the *facts*, afterwards published, the correctness of which is tested by my subsequent experience?

2. In p. 55, the Cornish tables of duty performed by the engines is quoted, and an *average* taken of their performance; this, again, is a most fallacious mode of treating the subject.

If none but the *improved* engines were taken, then an average might with propriety be struck; but it is obviously impossible to draw any correct conclusion as to the duty of the improved engines, from an average made up from returns in which the old or unimproved engines are included. It would be as reasonable to take a new hat and two old ones, and say that the average duration of the three afforded an indication of the quality and wear of the new one.

The engine referred to by me did a duty of 120 millions, for a *short time*, with very superior Welch coals, and I have no doubt that engines might be made to do this duty constantly; but my experience shows that, although not physically impossible, it would not be profitable to work the steam so expansively as would be necessary.

It is then stated, "It is useful to this inquiry that we have a statement of the performance of this engine;" but here is an error; there *is* a statement of the performance of this engine, but it is contained in my volume before referred to, which is not noticed in the Report, while the results given in my letter, which *are* quoted, are *not* those produced by a Cornish pumping engine, in comparison with an engine upon the old plan, but of the results produced at the East London Water-Works, after the introduction of my improve-

ments; and those results include, besides those of the Cornish engine, those of four other engines on the old principle, some or all of which were working, in addition to the Cornish engine, during the whole period.

A calculation is then entered into to show the performance of my engine to be (see p. 30, at top) 52,513,792 lbs. only: but this, as above stated, is the average duty of three old Boulton & Watt's engines and of one Cornish engine, and not of the Cornish alone, as is assumed in the Report.

The average duty done by the Cornish engine at Old Ford, during six years' constant work, has been 73,400,000 lbs., lifted one foot high by the consumption of 94 lbs. of *small Newcastle coals;* and so certain and regular is the result, that the work done by the engine is taken as the measure of value of the coals. A certain price is received by the contractor, if the coals supplied by him are of such quality as to produce this duty; — should the duty be less or more, then a proportionate deduction or addition is made from or to the price. A contract upon these principles has been entered into each year, for the last four or five years.

When the best Welch coals were used, (which generally *are* used in Cornwall,) the duty done by the engine was equal to 90,700,000 lbs., lifted one foot high, with 94 lbs. of coals; but as the price of these is in London greater than the others, in proportion to the work done, the inferior duty is found to be commercially the most profitable.

I do not know what variation in the quality of coals may exist in America, but in England it amounts to a difference of 40 per cent., and, in all calculations of duty, this must be considered; it being obvious that the same engine may perform 100,000,000 or 60,000,000, if two sorts of coal be used, the result depending upon the respective qualities.

If the gentleman, employed by the committee to make their calculations, will revise his estimate, I think he will find that my estimate of 657 tons per annum is correct, and not his of 915 tons. The calculation is so simple that two competent persons ought not to differ.

From the preceding remarks it will appear, I think, that my estimate of 72,000,000 duty, and of the quantity of coals required, remain as they were, and are not erroneous, as has been too hastily assumed.

In p. 43, the commissioners state that I have not calculated the friction of the pump, "which, it is presumed, is an oversight" in my computation for the power required. In reply, I beg leave to say, that I take it the effect produced represents the power, and that fric-

tion has nothing to do with it; but in my estimate of diameter of cylinder and power of engine, the power required for overcoming friction, working air pumps, &c. &c., is included, my estimate being founded upon the actual duty to be done by the engine; otherwise, indeed, this would have been an oversight.

The inexperience of the calculator is here again displayed, by his making a comparison between the friction of the pumps at the Philadelphia water-works, and that of a single plunger pump; the former having wheels which, according to the statements given, require (40 x 10 feet fall) 400 gallons falling 1 foot to raise (1 x 96 =) 96 gallons one foot, and as the wheel, if properly constructed, should be able to raise 96 gallons one foot high, by, at the most, 160 gallons falling one foot, then, according to his calculation, the friction of the pumps — the loss in the water-wheels, beyond what it ought to be — and the friction of the water through the mains to the reservoir, is equal to 240 gallons falling one foot; or, in other words, the effect is 96, while the power is 400; whereas, in the Cornish engine, at Old Ford, the loss due to the friction of the pump, and all the other parts of the machinery, is 2-10 of one pound per square inch of the cylinder.

With respect to my estimate, I may remark, generally, that I have no knowledge of any differences which may exist between the value of iron and machinery, or labor thereon, in England and the States; and that, of course, my estimates are founded upon my experience of cost here, and must be modified, when applied to countries in which prices are higher or lower. I may add, that the pumps are included in the amount put down for engines.

On p. 45, reference is made to the inquiries of the health of towns commissioners; and the evidence given by me is mentioned, for the purpose of quoting contradictory evidence given by Mr. Hawksley.

Now, it is not my desire, or my practice, to make remarks upon individuals; and I will only state, that my experience is considerable, and that the results which I have put forth are those produced by actual practice. The question, that my engine uses less coal, but employs more capital, is one which I am quite willing to leave to the decision of those whose pecuniary interest, in the various undertakings with which I am connected, leads them to scrutinize closely every item of expenditure; and, as the result of their accounts coincides with the expectation of my principles, I have no hesitation in adhering to my view of the subject. I may, however, state that, in four years after the introduction of the Cornish engine and standpipe at Old Ford, the saving in the expenditure, for carrying on the

works was equal to the total cost of the new works. And I may also state the fact, that I have had much experience in Cornish engines, as applied to water-works; whereas, I believe I may say, Mr. Hawksley has had none.

The question of what is called constant supply, as distinguished from the ordinary plan of supply by mains and services, referred to in the division of the Report relating to the quantity to be supplied, is one into which I have already more than once entered. I am now preparing a report on the subject, in reply to an application for my professional opinion, from a large water company in England; and I shall be happy to forward to you a copy of it, if I can obtain the permission of the directors to do so.

In conclusion, allow me to thank you for your courteous letters to me; and to say that, although I should like the correction of the errors, in the Report that I have alluded to, to be published, I am not desirous of entering into any disputes, having my time too fully occupied in my own business to volunteer combating for others.

I am, dear sir,

Yours, faithfully,

THOMAS WICKSTEED.

H. B. Rogers, Esq., &c. &c. &c.

It would seem that Mr. Wicksteed considers the reputation of our city as somewhat involved in this Report of the commissioners; and that he should not have noticed its hasty assumptions, "had not the document borne upon the face of it the *imprimatur* of one of the first cities in the United States." A like idea has been expressed to me by another eminent engineer, who writes, "I do not mean to say that Long Pond is not a good source of supply. But this Report certainly seems to me to be unworthy of the city of Boston in the year 1845."

I apprehend that no one can read this reply of Mr. Wicksteed without feeling *entirely* satisfied that the estimates given by him for the works contemplated in his letter to Mr. Eddy are fully sustained; and, indeed, more than sustained, in one point of practical importance which I shall have occasion to notice. To what a lamentable extent the hasty assumptions of the commissioners, by which they undertook to reconcile discrepancies which did not exist, affected the results of their calculations, we shall now proceed to point out.

It would seem, then, to be a clear case, that the estimates made by Mr. Wicksteed, in his letter to Mr. Eddy, are correct and reliable. The pumps and engines are adapted to work under a head of 150 feet, and the engine to perform a *duty* of 72 millions, instead of 52

millions, as was hastily assumed by our commissioners. In the language of the commissioners, "The bearing of this on estimates of fuel expense is too obvious to need further remark." (p. 36.)

But this is not all. The coal contemplated by our commissioners to be used, and on which they made their estimates, was good anthracite; while the duty assigned to his engine by Mr. Wicksteed appears to be based upon using *fine* (or "small") Newcastle coal. It becomes of some importance, then, to notice the difference, and qualify the duty, as the anthracite shall be better or worse than the small Newcastle.

On p. 40, the commissioners have given the relative evaporative power of several kinds of coal. They say that "its (anthracite) relative power, as compared with the best Cumberland coal tested, was 940 to 1000. Newcastle coal was found to have a power, as compared with the same Cumberland standard, of 809 to 1000." Hence it appears that the relative power of anthracite to Newcastle is as 940 to 809, and to "small" Newcastle undoubtedly more. Hence it would seem that an engine which, with Newcastle coal, performs a duty of 72 millions lbs. will, with anthracite, perform a duty of 83,646,477 lbs.; an addition of little more than 14 per cent.

As I feel no disposition to urge any points unreasonably, — indeed I feel disposed to stop short of the extent to which I think I might reasonably go — I wish to put it to the reader whether I am relying upon the engine in this case for a greater duty than it would perform, if tried? Am I not stopping considerably short of what might be relied upon, inasmuch as the duty taken at 72 millions is, in fact, on an experience of six years, near $73\frac{1}{2}$ millions; and the coals used were "small" Newcastle, while there can be no reasonable doubt that, in the experiments testing the power of that coal, a coarser and better quality was used.

Hence I regard it as proved, demonstrated, that in the kind of fuel provided in the estimates of the commissioners, a duty might be depended upon equal to $83\frac{6}{10}$ millions lbs. with every 94 lbs. coal; or almost exactly 89 millions with 100 lbs. coal.

On p. 34 I have showed, as I think, conclusively, that there is no occasion to throw the water into a reservoir higher, *on an average*, than 125 feet. And if it should be found expedient to have the load upon the pumps constant, and not variable with the rise and fall of water in the reservoir, it would be an important point to be considered whether the reservoir should not be enlarged in surface and reduced in depth. But as I intend to err on the safe side, I will assume that the engines work under the maximum pressure of 129 feet; and if there be any advantage (as I think there must be) in

working under a less during a part of the time, I will not base any calculation upon it.

I shall therefore assume as proved, that by the exact circumstances of our case, the engine provided for by Mr. Wicksteed, in his letter to Mr. Eddy, to work under a pressure of 150 feet, will, in fact, be required to work under a pressure of only 129 feet; and that, from the use of a better quality of fuel, a duty may be obtained of 89 millions lbs. with every 100 lbs. of anthracite coal.

Let us now look at Mr. Wicksteed's estimates of the expense of engines and apparatus; i. e., the fixed capital required.

Mr. Wicksteed's estimate for one engine, to raise 2 millions imperial gallons daily, 150 feet high, is as follows:

	£ s. d.
1. Engine and boilers	7,500 0 0
2. Engine house, boiler house and chimney	3,700 0 0
3. Stand pipe 150 feet high, and foundation	3,300 0 0
4. Reservoirs and filter beds	7,000 0 0
5. Sundry works	2,000 0 0
6. Contingencies, including engineering	4,700 0 0
	£28,200 0 0

As in our case the water is to be forced but a short distance, and nearly perpendicularly, the commissioners dispense with a stand pipe and foundation, (item No. 3,) and allow the amount of their cost to balance the expense of reservoir and pipe from engine to reservoir; and they dispense entirely with item No. 4.

The commissioners have altered this estimate of Mr. Wicksteed to the following form, p. 44:

1. Engine and boilers	£7,509	£8,700
2. Increased power required as before stated, 16 per cent.	1,200	
3. Engine house, boiler house, and chimney		3,700
4. Sundry works, (supposed to include pump)		2,000
5. Stand or slope pipe and summit reservoir		3,300
6. Contingencies and engineering		4,700
		£22,400

Equal to $108,316, (should be $108,192.)

It may be worth while to notice that there is a difference between the wine gallon of Mr. Wicksteed and that of the commissioners; Mr. Wicksteed's weighing 8 lbs., and that of the commissioners, 8.35 lbs. Mr. Wicksteed's estimate is for raising 2 millions *imperial* gallons per day, and the commissioners quote him as for $2\frac{1}{2}$ millions *wine* gallons per day. The difference is near 100,000 wine gallons

per day. As, however, my object is to follow our commissioners, I shall not further notice this discrepancy.

In this estimate of the commissioners, it will be observed that item No. 2 is an entire mistake, as explained in Mr. Wicksteed's remarks, and must be omitted. No. 4 was supposed by the commissioners to embrace pumps; but Mr. Wicksteed informs us that pumps were embraced in item No. 1. What the "sundry works" of Mr. Wicksteed did embrace, I do not know; but it is probable it was intended to cover some incidental or preparatory work which the commissioners have otherwise provided for. Although I do not know that this is so, yet as it is certain that pumps are not embraced in it, I feel at liberty to reduce this item to £1000. It is still further to be noticed that Mr. Wicksteed allows 20 per cent. (£4,700) for "contingencies, including engineering." Now, as the commissioners have not in the other portions of the work made so large an allowance, it clearly ought not to have been done here. The most that should be allowed here is the 10 per cent. which has been elsewhere allowed for contingencies.

Making these deductions, the table should stand thus:

1. Engine and boilers	£7,500
2. Engine house, &c.	3,700
3. Sundry works	1,000
4. Stand or slope pipe and reservoir	3,300
5. Contingencies, 10 per cent.	1,550
	£17,050

Equal to $83,351.

Now, I again ask if this be not a fair, perfectly fair, estimate, upon the basis of Mr. Wicksteed; and ought not the table of the commissioners to be correct accordingly? It must be conceded to be so.

But this was an estimate for working under a head of 150 feet. Our commissioners did not propose to have the head over 140 feet; and yet they have not allowed one cent difference. Is this right? Is it fair?

Although the other items, embracing appurtenances which must be on about the same scale, whatever shall be the power of the engine, I apprehend that there can be no good reason why No. 1 (engine and boilers) should not be reduced in nearly the same ratio in which the intended work is reduced. It may not be exact, but it cannot be far from correct. Reducing this item in the ratio in which the head is reduced, (say 21 feet,) and the table will be as follows:

1. Engine and boilers	£6,450
2. Same as before	3,700
3. Same as before	1,000
4. Same as before	3,300
5. Contingencies, 10 per cent.	1,445
	£15,895

Equal to $76,873.

Estimate of commissioners	$108,316
" corrected, as it clearly should be	76,873
Overestimate of the commissioners	$31,443

But this is on *one* engine. The commissioners have provided for *four*. Though this is one more than I should think necessary, and one more than practically ever would be built for the work, I do not propose to reduce the number.

The 2d engine the commissioners estimate, (p. 55)	$65,340
Mr. Wicksteed estimates it at £12,300; but, corrected for less pressure, should be	£11,250 = 54,337
Overestimate of the commissioners	$11,003

On p. 56, the commissioners estimate the cost of engines 3 and 4 at same as No. 1 and 2, say	$173,656
Add for slope pipe	3,000
	$176,656

We have shown that the first costs only	$76,873
And the second only	54,337
To which add for slope pipe	3,000
The cost of third and fourth engines, &c.	$134,210
Which, taken from estimate of commissioners	176,656
Overestimate of commissioners	$42,446

Let us now sum up the overestimates of the commissioners, viz.:

1. On pipe from summit reservoir to Corey's Hill	$26,080
2. On 1st engine, &c.	31,443
3. On 2d do.	11,003
4. On 3d and 4th do.	42,446
Total	$110,972

" The total cost (say the commissioners, p. 119) of obtaining a daily supply of $7\frac{1}{2}$ millions gallons from Charles River, will be $146,973 more than to obtain the same quantity from Long Pond."

If from from this balance against Charles River . .	$146,973
We take the above overestimates	110,972
The balance against Charles River is reduced to . .	$36,001

I now propose to say a few words upon the estimates of commissioners for land and water damages; and first of those of Long Pond. These the commissioners estimate at the gross sum of $165,000. No one is more sensible than myself of the difficulty of arriving at a fair estimate of the damages under consideration; and no one is more sensible than myself of the impolicy of public commissioners putting them at a very high rate. Still, I must enter my protest against the continued repetition of estimates which nobody places any confidence in. I apprehend there is not a citizen of Boston sufficiently verdant to expect to liquidate these legal claims for damages for any sum near the one named by the commissioners. I entertain no doubt that if those who are legally interested in the matter should offer to compromise their claims for the gross sum of $300,000, nine out of every ten citizens who have given any attention to the subject, would think the public interest of the city unreasonably jeopardized by a rejection of the proposal.

Now let us look at Charles River. The commissioners, on the authority of somebody, not named, puts the water right at Watertown at $50,000; and they urge the importance of purchasing the whole right. Though I *think* it certain that the whole might be obtained for considerably less than $50,000; I *know* that the right to draw three times as much water as the commissioners found sometimes running in the river by their guage, could be obtained for less than $25,000. At that very time I had in my power a clear well-defined right, subject to no control or interference from other owners, (who had no right to draw a gill till I had drawn to the extent of my right,) to draw near or quite 30 millions gallons per day. This right was at the service of the city for $25,000.

Why, then, it was important to buy the other rights, which could scarcely be anything more than rights to use surplus water, and pay therefor $25,000, it is difficult to conjecture.

I do not intend, however, to go minutely into these matters. I mean merely to convey the idea, in which I believe nearly every one will acquiesce, that the estimated damage for water rights in the Long Pond plan is too small; and that in the Charles River plan is too large. And between the two I intend to claim the sum of $36,000; a sum which, though not demonstrably allowable, I believe few would feel disposed to question the reasonableness of.

Taking this for granted, I have shown that, on the basis of Mr.

Wicksteed's estimates, corrected to the exact circumstances of our case, and substituting one large pipe for two smaller ones between the country reservoirs, and leaving all the other estimates just as the commissioners have left them, 7½ millions wine gallons daily can be delivered on Corey's Hill as cheaply from Charles River as from Long Pond. I do not see how a fair-minded man can resist the force of the calculations that lead to this result.

What, then, are the advantages claimed by me for the Charles River plan, over the Long Pond plan? I will proceed to state them.

On pp. 121 and 2, the commissioners give, in the following table, their views of the increase of the city. To this I do not object, though it seems to exhibit rather a rosy tint. I should not, however, be satisfied with any scale of works that would not be adequate to meet the reasonable demands of as large an increase of population as is here contemplated, and within the time specified.

The present population is	115,000
Estimated increase in the next 5 years, at 25 per cent. .	28,750
The population at the end of 5 years	143,750
Estimated increase in the 2d 5 years, at 20 per cent. .	28,750
Population at the end of 10 years	172,500
Estimated increase in the 3d series of 5 years, at 12 per cent.	20,700
Population 15 years from this time	193,200
Estimated increase for the 4th series of 5 years, at 10 per cent.	19,320
Population at the end of 20 years	212,520

To this estimate I propose to add a population of 37,480, — making the whole 250,000, — to be attained in 10 additional years, or in 30 years from the present time. This seems to be necessary in order to attain a population that shall, on the quantity allowed by the commissioners to each inhabitant, create a demand for the whole of the supply proposed to be furnished. And as the number proposed for increase in these additional 10 years is very nearly double the increase of the preceding 5 years, I presume that no objection will be made to its reasonableness.

The commissioners propose to supply 30 gallons to every individual of population. We begin, then, with a population of 115,000, and a demand for (115,000 × 30) 3,450,000 gallons per day; and we go on, at various rates of increase, so that in 30 years we come to a population of 250,000, and a demand for (250,000 × 30) 7,500,000 gallons per day, the full amount on which the estimates are made.

I propose, then, to enter into a calculation, and see what difference it will make to the city at the end of 30 years, when the $7\frac{1}{2}$ millions will first be called for, whether it select Long Pond or Charles River as the source of supply. This is a point entirely overlooked by the commissioners. But I apprehend the results will show that they might about as well have overlooked everything else.

There is, I apprehend, no pretence that economy in construction of conduit or pipes from either source, would be greatly advanced by leaving additions to be made as the demand should increase. I am not sensible that anything could be gained on the Long Pond route, except the expense of one pipe of 3000 feet, for a few years. But, as on the Charles River plan, a line of pipes of 8000 feet, though smaller, might be deferred for equally long time, it can be no injustice to the Long Pond plan to suppose every part of both works to be constructed at the outset for the full amount, ($7\frac{1}{2}$ millions,) except the engines and appurtenances; which should be furnished when needed.

As we commence with a demand greater than $2\frac{1}{2}$ millions per day, the only item of construction that can be deferred, is the 4th pump and appurtenances, which is same as cost of 2d pump, $54,337.

At the rate of increase proposed by the commissioners, in 9 years the number of inhabitants will be 166,750, which, at 30 gallons per head, will come up to a consumption of 5 millions per day; and then I would propose the 4th engine should be erected.

What, then, would be the saving in 30 years, arising from deferring the erection of the 4th engine for 9 years? *Clearly the compound interest on* $54,337 *for* 9 *years, when the principal is to be deducted, and compound interest to be calculated on the remainder for* 21 *years.*

$54,337 in 9 years, amounts to	$84,294
From which take the principal then put into the engine .	54,337
Leaves	$29,957

This sum, in 21 years, amounts to very nearly $89,871. I say very nearly, because in this case and the following, I assume that a sum doubles in 14 years, at 5 per cent.: which is not exactly the case, though very nearly.

We now go to the current annual expenses. It must be borne in mind that what we are now aiming at is to show how differently the city will stand 30 years hence, when the demand is assumed to be $7\frac{1}{2}$ millions gallons per day, if the Charles River plan be adopted, from what she will if the Long Pond plan be adopted. In estimating

the annual saving, therefore, in current expense, we do not get the whole; for, in order to compare one plan with the other, the current expenses are represented by a capital which, at 5 per cent., would yield a sum sufficient to pay them. *Whatever sum there is saved in any one year, represents a capital, the use of which is deferred one year; and the real saving on that year, 30 years hence, is the interest on that capital for one year, compounded at 5 per cent. for the complement of 30 years.* But as the calculation for each year would be complex and tedious, I propose to divide the whole term into periods of five years.

To pump $7\frac{1}{2}$ millions gallons per day, the commissioners estimate (p. 58) the current expense at $34,386, — representing a capital of $687,731.

We begin with	115,000	inhabitants.
In 5 years we have	143,750	"
	$\frac{1}{2}$ 258,750	"
Gives	129,375	"

the average number to be supplied during the first 5 years; and, at 30 gallons per head, the quantity to be pumped daily will be 3,881,250 gallons. Our first inquiry is, what will be the annual current expenses of pumping this quantity?

We have seen that the engine will raise 89 millions lbs. = 10,658,682$\frac{1}{2}$ gallons, 1 foot high, with 100 lbs. coal; or, what is equivalent, 3,881,250 gallons 1 foot high, with 36.414 lbs. coal. Hence, to raise this latter quantity 129 feet, will require $36.414 \times 129 = 4697.4$ lbs. per day, or $\times 365 = 1,714,551$ lbs. per annum. This is = 765.425 gross tons, which, at $6 per ton, (the price estimated by the commissioners,) will cost $4,593 per annum.

The other annual expenses are put down by the commissioners, p. 57, for raising 5 millions per day. I am entitled to a reduction in the three last items, on account of the diminished work and value of the engines; but for this I will take some equivalent in the next period of 5 years.

Say 1st engineer	$821,25
Two assistants	1277,50
Four firemen	1825
Oil, hemp, &c.	1452
Repairs, &c., 2 per cent. on $277,972 . .	5559,44
Insurance, $\frac{3}{4}$, valued 1 per cent. . .	2084,79
	$13,019,98
Add for coal	4,593
Total annual expense in the first 5 years	$17,613

This represents a capital, at 5 per cent. of	$ 352,260
Take this from the estimate of the commissioners above	687,731
Leaves amount uncalled for in 5 years	$ 335,471

The interest accruing on this sum in 5 years, is $92,684; and this, in the remaining 25 years, amounts to $317,861.

In the *second* period of 5 years the average number of inhabitants to be supplied will be $\frac{143,750+172,500}{2} = 158,125$. At 30 gallons each, 4,743,750 gallons will be in demand daily. To raise this amount requires 936.255 gross tons coal; which at $6 = $5,618 per annum. The other expenses of this period will be same as in the first 5 years, except the last or tenth year, when it is supposed the 4th engine will be put in, and some provision be made for working it a small part of the time. But, as I have allowed the full amount of incidental expenses as estimated by the commissioners when I was justly entitled to a reduction, I think I have allowed fully enough for all the practical extra expense required in the 10th year. I shall, therefore, consider the other annual expenses in this

5 years, same as in the first	$ 13,020
Add for coals	5,618
Total	$ 18,638
This represents a capital	$ 372,760
Take this from estimate of commissioners	687,731
Leaves amount uncalled for in 10 years	$ 314,971

The interest accruing on this sum in 5 years, is $87,021; and this in the remaining 20 years, amounts to $248,010.

In the *third* period of 5 years the population will average $\frac{172,500+193,200}{2} = 182,850$; and the daily demand for water 5,485,500 gallons. To raise this quantity will require 1,082½ gross tons coal, at $6 = $6,493.

The other expenses must now be estimated on 4 engines; but as I am going to claim no offset for any overestimate before of the commissioners, I shall now reduce this estimate of incidental charges to the reduced work and value of the machinery. See table of the commissioners, p. 58.

Engineers and firemen, same as commissioners	$ 5,475
Oil, &c., reduced as 150 to 129	1,873
Repairs on building and machinery, leaving out slope pipe and reservoirs, &c., say $ 200,000, at 2 per cent.	4,000
Insurance on $ 175,000, at 1 per cent.	1,750
	$ 13,098

This I regard as a liberal estimate ; and if any one will go through the details, I believe it will be found so.

The annual expense for the *third* period of 5 years, will be, for coal	$ 6,493
And for other expenses	13,098
	$ 19,591
This represents a capital of	$ 391,820
Take this from estimate of commissioners . . .	687,731
Leaves amount uncalled in 15 years . . .	$ 295,911

The interest accruing on this sum in 5 years, is $81,755 ; and this, in the remaining 15 years, will amount to $171,685.

In the *fourth* period of 5 years the average population will be $\frac{193,200+212,520}{2} = 202,860$; and the daily demand for water 6,085,800 gallons. To raise this will require 1200 gross tons coal ; which at $6 will cost

	$ 7,200
Other expenses, as before	13,098
	$ 20.298
This represents a capital of	$ 405,960
Take this from estimate of commissioners . . .	687,731
Leaves uncalled for in 20 years	$ 281,771

The interest accruing on this sum in 5 years is $77,773 ; and this, in the remaining 10 years, will be $113,744.

If we allow half the increase of 10 years, to come upon the *fifth* term of 5 years, as it no doubt should, the population will average in that term 221,890; and the daily demand for water will be 6,656,700 gallons. To raise this quantity will require 1314 gross tons coal ; which, at $6, will cost

	$ 7,884
Other expenses, as before	13,098
	$ 20,982
This represents a capital of	$ 419,640
Take this from estimate of commissioners . . .	687,731
Leaves uncalled for in 25 years	$ 268,091

The interest accruing on this sum in 5 years, is $74,069 ; and this in the remaining 5 years will amount to $94,532.

In the *sixth* period of 5 years the average population will be 240,630 ; and the daily demand for water will be 7,218,900 gallons.

To raise this quantity will require 1424 gross tons coal; which, at $6, will cost

	$8,544
Other expenses, as before	13,098
	$21,642
This represents a capital of	$432,840
Take this from the estimates of commissioners . .	687,731
Leaves uncalled for in 30 years	$254,891

The interest accruing on this sum in 5 years, is $74,422.

Here we arrive at the period of 30 years, when the population is supposed to be 250,000, and the demand for water is $7\frac{1}{2}$ millions gallons per day. Here I propose to stop, although it is obvious that the advantages of the river scheme over the pond scheme is not attained until we arrive at a period when the current expenses of pumping shall represent the sum estimated by the commissioners, $687,731; a period apparently far distant at the end of the 30 years.

We will now sum up.

Saving arising from deferred expense of 1 engine 9 years	$89,871
" " " current expenses in 1st 5 years	317,861
" " " " " 2d "	248,010
" " " " " 3d "	171,685
" " " " " 4th "	113,744
" " " " " 5th "	94,532
" " " " " 6th "	74,422
Total	$1,110,125

Thus it appears that by adopting the Charles River plan, the city will save, in 30 years, ONE MILLION ONE HUNDRED AND TEN THOUSAND ONE HUNDRED AND TWENTY-FIVE DOLLARS; a sum greater than the whole estimated cost of the Long Pond works to Corey's Hill, including the reservoir.

In coming to this result I must repeat that I have endeavored to go upon no doubtful data, or to press doubtful points. All the calculations have been made by myself, except in the instances where the formula of Prony has been applied to the discharge of pipes; in these cases the calculations have been made by a friend. Possibly, in my work some errors may be found; for the reader must be aware that my labors are not paid for at such a rate as to command the degree of attention necessary to secure perfect accuracy. I, however, am aware of no mistakes; and if they have occurred, they are as likely to be against me as in my favor. I have already

stated that, in casting the interest on long periods, I have considered the sum as doubling in 14 years, — which is not precisely accurate, but the error cannot be important.

Now, if these calculations are made on a basis that cannot be shaken; if they come as near to demonstration as the nature of the subject will admit, as I believe they do, — is it too much to ask of the reader to weigh this final result fairly, and without bias. Consider how far the saving here proposed would go to furnish the school houses, and the enlargement of our eleemosynary and disciplinary institutions, which the increase of the city is certain to render necessary. Then let him determine what the city ought to do, on precisely the same grounds as if the matter were one of individual concern, and the whole results were to rest on his own shoulder.

But my case is by no means closed with the above result. I have allowed 30 gallons to every inhabitant, as soon as he appears on the stage. Now, I believe this is too much *by one half.* I do not mean to express the opinion that the city will not arrive to a consumption of 15 gallons per head daily, though I am not prepared to admit that that is not a reasonably supply; but I mean to say that, in my opinion, the consumption for the first 15 years will fall so much short of an average of 15 gallons per head daily, as to allow the consumption after that period to far exceed that average, and still the expense for pumping during the whole period of 30 years will not exceed that necessary for delivering 15 gallons per head daily. The greatest saving will be in the first years, when from the interest accruing it will tell most favorably upon the final result.

The results, then, to which I have arrived, seem to me conclusively to show, —

1st. That in no single point is the water of Long Pond proved by this Report, taken with other facts, to be superior to that of Charles River.

2d. That the water in Charles River is much the most abundant. And,

3d. That the expense of introducing a supply from Charles River, in any quantity as it may be needed, is very much less than from Long Pond; — say $1,110,125.

I had intended to add to this review some remarks upon the importance of securing an universal use, as distinguished from an universal abuse, of the water, when it shall be introduced. But, as the labor of this review has been much greater than I expected, and as it has been already protracted to a length which I fear the reader will regard as tedious, I have thought it best here to dismiss the subject.